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A FORMAL THEORY OF VOWEL COALESCENCE

A Case Study of Ancient Greek

W.G. DE HAAS

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een wetenschappelijke proeve op het gebied van de letteren

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan

de Katholieke Universiteit te Nijmegen,

volgens besluit van het college van decanen in het

openbaar te verdedigen op

maandag 31 oktober 1988

des namiddags te 3.30 uur

door

WILLEM GERRIT DE HAAS

geboren op 11 januari 1957 te Lienden

Promotor: Prof. Dr. B.H. Bichakjian

Co-referent: Dr. W.L.M. Wetzels

for Ellen and Lotte

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ACKNOWLEDGEMENTS

This thesis would not have been possible without the moral and intellectual support of many people both inside and outside the field of linguistics. I would like to take this opportunity to thank in addition to my director Nick Clements for his listening and criticizing my ideas on the description of vowel coalescence and underspecification, professor C.J. Ruijgh for his careful reading of three earlier versions of the chapters on Ancient Greek, as well as for his valuable suggestions for improvement, Wim Zonneveld for introducing me to generative phonology, for being a permanent source of inspiration, and for his careful reading and commenting on the entire manuscript.

I am also grateful to Lisan van Beurden, Jan Don, Carlos Gussenhoven, Ben Hermans, Haike Jacobs, René Kager, Hans van de Koot, Wus van Lessen Kloeke, Jan Nijen-Twilhaar, Det Paulissen, Willebrord Sluyters, Mieke Trommelen, Ellis Visch and Jetty Wester for supporting me both as friends and fellow linguists.

Furthermore, I thank all members of the French Department, in particular Els Bronzwaer with whom I shared an office, and Hanneke Khalil, who succeeded in creating a stimulating academic environment.

Finally, I would like to thank my present employer, the Institute of Dutch Lexicology, and particularly professor P.G.J. van Sterkenburg, for giving me the opportunity to finish this dissertation.

This thesis was written when I was a research assistent at the Catholic University of Nijmegen (University Research-Pool project L 1/84), and for seven months a visiting scholar at the Department of Modern Languages and Linguistics of Cornell University. My stay at Cornell was made possible by a grant from the Netherlands Organization for the advancement of research (N.W.O.).

INTRODUCTION

The central topic of this study is the formal description of vowel coalescence from the perspective of Universal Grammar. As such it is intended as a contribution to the current study of the formal content of linguistic theory. In particular, this thesis seeks to modify and redefine a number of formal notions. We will examine the phenomenon of vowel coalescence in a variety of languages, but special attention will be paid to the description of the intricate system of vowel coalescence in Ancient Greek.

Vowel coalescence or vowel fusion is a process by which two vowels in hiatus - which roughly corresponds to two vocoids on the borderline of two syllables - merge into a single vowel, which can be considered an 'articulatory compromise' of the input segments. Some examples are presented in (1):

(1) a: Ancient Greek

/tīma-o-men/	→ [tīmɔ̄̂men]	'honor' (1.pl.pres.ind.)
/aydo-a/	→ [aydɔ̄̂]	'shame' (acc.sg.)

b: Classical Sanskrit

/raja indra/	→ [rajēndra]	'supreme souvereign'
/hita upadēśaḥ/	→ [hitōpadēśaḥ]	'friendly advice'

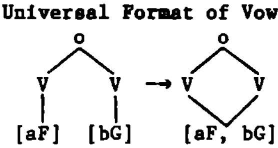
c: Korean

/cu-ə/	→ [cō]	'to give'
/na-eke/	→ [nǣke]	'to me'

The main questions this study attempts to answer are (i) how to account for the basic characteristics of vowel coalescence within the framework of generative phonology, and (ii) how to restrain phonological theory so as to exclude coalescence processes that do not occur in human languages, and, at the same time, make it powerful enough to account for those coalescence processes that do occur.

The idea we will develop and motivate is that all examples of vowel coalescence are expressible in the universal format in (2), possibly supplemented by language-specific conditions:

(2) Universal Format of Vowel Coalescence



This format makes the claim that vowel coalescence is confined to the domain of the syllable, and that the lexically marked or dominant feature values of both input vowels are preserved in the course of fusion. A further aspect of the format in (2) is that the output is predicted to be a long vowel, a prediction which seems to be borne out by the facts in (1). In this way we express that both the quantity and quality of the output are derivatives of the quantity and quality of the input.

From a theoretical point of view, the format in (2) deviates from that usually assumed in nonlinear phonology. In broad outline, this framework assumes that phonological rules take the form of deassociation, association or spreading operations, while the rule in (2) is essentially a merger operation. This study will provide empirical support for the claim that merger must be regarded as a primitive operation in phonological theory.

It will be clear from the preceding that the theory adopted here is that of autosegmental phonology which has been developed in the recent past in important studies such as Goldsmith (1976), Halle and Vergnaud (1980), Steriade (1982), Clements and Keyser (1983), Clements (1985) and Hayes (1986a). These studies represent a line of research that entails a radical break with the standard theory of phonology as developed in Chomsky and Halle's The Sound Pattern of English. First, they represent a change of focus in the study of phonology similar to the changes that have occurred in the area of syntax, viz. there is a shift away from the study of rule systems in the direction of the study of principles governing the application of rules. Second, this line of research has developed a much richer conception of phonological representation than the strictly linear one of Chomsky and Halle. Phonological representation is now looked upon as three-dimensional. It consists of a string of skeleton or timing slots, onto which layers for tone, stress, and the qualitative aspects of the phonemes are projected. To a large extent, we will assume familiarity with these contributions to phonological theory, but in the course of the exposition we will outline those aspects that are important for the theory to be developed.

This thesis is roughly composed of three parts. Chapters 1 and 2 are basically theoretical in nature. They outline, respectively, some of the subtheories underlying this study, and the general outline of the formal theory of vowel coalescence. Chapters 3 and 4 are devoted to a detailed analysis of the phonology of Ancient Greek, and in particular to the interaction of the major vowel rules with vowel coalescence. Finally, chapter 5 puts the theory advanced to the test, on the basis of an examination of vowel coalescence or apparent vowel coalescence processes in a number of unrelated languages.

The actual exposition takes the following course. In chapter 1, we will go into the form and content of phonological representations, the relations holding among phonological features, and general constraints on the application of phonological processes. In section 1.1, we will outline a theory of hierarchical feature representation which deviates from recent proposals by Clements (1985) and Sagey (1986b) in the way hierarchical structure is erected. Another aspect of feature representation, viz. the amount of specification necessary to distinguish the sounds of a language in underlying representation, will receive attention in section 1.2. We will propose a theory of underspecification which resembles the Prague School approach, as well as the approach independently put forward in Steriade (1987b). Sections 1.3 and 1.4 contain two related topics concerning constraints on the application of phonological rules. In the former, we will deal with the Linking Constraint; a condition which states that association lines mentioned in the structural description of a rule must be interpreted exhaustively. An attempt will be made to extend the scope of this constraint to all processes referring to two autosegmental levels including purely segment-internal processes that require mentioning of association lines. Section 1.4 consists of an outline of the principles of Lexical Phonology and of a discussion of a second constraint on the application of phonological rules, viz. the Strict Cycle Condition. We will suggest, following Kiparsky (1982) and Hermans (1986), that the Strict Cycle Condition is not a primitive of linguistic theory. The effects, which were previously assigned to this condition are derivable from independently motivated principles such as the Elsewhere Condition or the Projection Principle.

In chapter 2, we move on to a consideration of the properties of vowel coalescence and the way in which these should be captured in an explanatorily adequate phonological theory. We will begin by examining a number of possibilities of avoiding vocalic hiatus, after which we limit our attention to the most intriguing option, viz. that of vowel fusion. A survey of the linear as well as nonlinear literature on this issue (section 2.1), will be followed by our proposal in which vowel coalescence is regarded as feature-node coalescence which operates exclusively within the domain of the syllable. Evidence will be presented showing that the introduction of merger as a primitive autosegmental operation cannot be prohibited on either theoretical or empirical grounds. Furthermore, empirical evidence will be adduced to support the claim that vowel coalescence is confined to tautosyllabic vocoids.

Chapter 3 will provide a detailed examination of the patterning and representation of vowels in the Attic dialect of Ancient Greek. The diachronic evolution of the vowel system will receive attention first, and next (section 3.2), we will outline a synchronic proposal for the representation of the Attic vowel system on the basis of the various subtheories developed earlier, in particular underspecification theory. In section 3.3, we will seek to motivate this proposal on language-internal grounds, which range from stem-vowel alternations, word-formation processes supplying the default vowel /e/ to a number of major vowel rules, such as Stem Vowel Lowering and /ā/-Fronting. Finally, we will take into consideration the recalcitrant process of Metathesis of Quantity, and it will be shown that the theory advocated here allows a considerable simplification of this rule in comparison with earlier accounts.

In chapter 4, we will deal with the complex system of vowel coalescence in the Attic dialect and it will turn out that the theory of underspecification developed in chapter 3 enables us once again to simplify the formal statement of this process. The presentation of the facts of vowel coalescence and its characteristics (section 4.1) will precede a discussion of illegal rule telescoping. It will be argued that the facts of vowel coalescence and compensatory lengthening cannot be derived from a single rule of Vowel Coalescence and a single rule of Compensatory Lengthening. We will show that a rule of Leftward Spreading accomplishes e+V mergers, while an independent rule of Vowel Coalescence proper resolves the remaining types of vocalic hiatus. The facts of compensatory lengthening will be shown to result from the application of two rules, one being a coda migration rule and the other being a simple syllable-weight preservation rule. A number of arguments will be given to support the claim that positing only one rule of vowel coalescence and one rule of compensatory lengthening leads to undesirable rule telescoping and a considerable loss of generality. In section 4.3, we will outline the formal description of Vowel Coalescence proper, and it will be argued that this process is activated by a rule of resyllabification which initiates the resolution of vocalic hiatus. Furthermore, we will consider a set of empirical problems and show how they should be accounted for within the theory advanced. The behavior of high vowels in hiatus will wind up the discussion of vowel coalescence in Ancient Greek, and we will provide an explanation for the fact that high vowels in prevocalic position resist both resyllabification and merger, while postvocalic high vowels undergo resyllabification but fail to undergo subsequent vowel fusion into a monophthong.

The third part of this thesis examines vowel coalescence from a cross-linguistic perspective. A number of languages for which rules of vowel coalescence are posited in the literature will pass in review. We will demonstrate that only a subset of these shares the basic characteristics that vowel coalescence processes must satisfy. In section 5.1 to 5.4, we will take into account languages which have to be considered true vowel coalescence languages. One of these is Quebec French as it is a representative of a true vowel coalescence language which distinguishes nasal and oral vowels. This language will provide clear evidence that besides the vocalic features also the marked or dominant nasal feature is preserved under contraction. In section 5.2, we will examine Korean and Rotuman to see if these languages refute or confirm the widely assumed notion of structure preservation. It will be argued that vowel coalescence refutes the claim that lexical processes cannot give rise to sounds that do not occur underlyingly. In both languages the front rounded vowels arise by coalescence, although they do not belong to the underlying sound inventory. Finally, we will consider Old Portuguese and Classical Sanskrit, since these languages exemplify an interesting bifurcation among the vowel coalescence languages. Old Portuguese will be shown to pattern with Ancient Greek, because high vowels do not participate in vowel coalescence proper, while Classical Sanskrit will be shown to pattern with such languages as Quebec French and Korean, because high vowels do undergo vowel coalescence. In section 5.5, we will discuss a number of apparent vowel coalescence languages, in which the apparent mergers are a by-product of independently motivated processes. The Kasem vowel mergers will be shown to arise from the interaction of the rules of Vowel Lowering and Degemination. It will turn out that the Kikuyu a+V mergers are the result of [ATR]-Spreading and Compensatory Lengthening. In addition, we will argue that the apparent mergers in Tunica are the result of rules of Vowel Harmony and Vowel Syncope. Finally, for Washo infixing reduplication we will argue that the vowel changes in the reduplicated form are the result of two independent rules of vowel-to-vowel assimilation of a rather trivial type, in conjunction with independent principles of reduplication such as infixing of an empty CV syllable, stem copying and automatic left-to-right association.

1.0 Introduction

A fundamental task of phonological theory is to establish how phonological forms and processes should be represented, and what the relations and constraints that hold between rules and representations are. Ideally, a phonological theory must be restricted enough to exclude those forms and processes that do not occur in human languages, and powerful enough to account for the forms and rules that do.

A second central task of the theory is to provide a means of discriminating between marked and unmarked forms and rule types. For example, assimilation rules are far more natural than metathesis rules; assimilation of a whole group of features is more common than assimilation based on a single feature; and metathesis always involves the permutation of sounds, while the permutation of single features seems unattested cross-linguistically.

In the past decade it has been convincingly shown that a nonlinear theory of phonology is preferable to linear or segmental theories of the type most prominently argued for in Chomsky and Halle's The Sound Pattern of English (henceforth SPE). For example, Halle and Vergnaud (1980) and Steriade (1982) suggest that there are great advantages in representing assimilation as feature spreading instead of representing it as the change of feature values contained in the phonological matrix. The main reason is that assimilation conceived as spreading makes it impossible to represent assimilations in which the target acquires a feature which is not present in the trigger. In point of fact, the rule formalism assumed in segmental phonology does not discriminate, in terms of markedness, between an assimilation rule in which the target takes the feature [+F] if the trigger is characterized as [+F], and an assimilation rule in which the target acquires [+F] irrespective of the fact whether the trigger is [+F] or [-F], a type of assimilation rule not attested. Thus, autosegmental spreading is a more constrained way of representing assimilation, because it correctly rules out assimilation rules of the second type. Moreover, it explains why assimilated clusters behave like geminates with respect to rules of epenthesis, since in both cases the adjacent sounds share at least one feature.

The aim of this thesis is to contribute to these central goals by developing a formal theory of vowel coalescence which restricts the range of coalescence processes in a nontrivial sense. Vowel coalescence is the merger of two adjacent vocalic sounds into a single diphthong or monophthong. The latter change is the more interesting one, since the output is in many cases different from both input vowels, e.g. e+a → ɛ̄ or o+e → ǿ. Typically, changes of the following type seem to be systematically excluded: ɛ+o → ā or o+a → ū. In earlier reports on the present research (De Haas 1986a, 1987a), it was noted that the output of coalescence is the result of the spreading of so-called 'dominant' feature values. In the present study we will argue that we can dispense with this notion if we adopt a particular version of underspecification theory (cf. Kiparsky 1982, 1985, Archangeli 1984, and section 1.2).

For a proper understanding of the formal account of vowel coalescence, to be developed in chapter 2, it is necessary to make explicit the various subtheories underlying this account. Hence, the remainder of this chapter will be devoted to a detailed outline of these subtheories. In particular, we will propose a theory of hierarchical feature representation as the result of tier decomposition, that is, the autosegmentalization of (groups of) features contained in a phonological matrix (section 1.1). A second subtheory, to be developed in section 1.2, is that of underspecification. In addition, in sections 1.3 and 1.4. we will enter into the details of two important constraints on the application of phonological rules, viz. the Linking Constraint (cf. Hayes 1986a, Itô 1986), and the Strict Cycle Condition (cf. Mascaró 1976, Kiparsky 1982, 1985).

1.1 The representation of distinctive features

In SPE all features are contained within a phonological feature matrix without internal structure, that is, features are unordered and unrelated. A word like bank, for instance, could be represented as in (1a) below. The rule of place assimilation (1b) turns the representation (1a) of bank into (1c):

(1) a:
$$\begin{array}{cccc} \begin{bmatrix} -\text{syll} \\ +\text{ant} \\ -\text{cor} \\ -\text{nas} \\ \vdots \end{bmatrix} & \begin{bmatrix} +\text{syll} \\ -\text{ant} \\ -\text{cor} \\ -\text{nas} \\ \vdots \end{bmatrix} & \begin{bmatrix} -\text{syll} \\ +\text{ant} \\ +\text{cor} \\ +\text{nas} \\ \vdots \end{bmatrix} & \begin{bmatrix} -\text{syll} \\ -\text{ant} \\ -\text{cor} \\ -\text{nas} \\ \vdots \end{bmatrix} \\ \text{b} & \text{a} & \text{n} & \text{k} \end{array} \qquad \begin{array}{cccc} \begin{bmatrix} -\text{syll} \\ +\text{ant} \\ -\text{cor} \\ \vdots \end{bmatrix} & \begin{bmatrix} +\text{syll} \\ -\text{ant} \\ -\text{cor} \\ \vdots \end{bmatrix} & \begin{bmatrix} -\text{syll} \\ -\text{ant} \\ -\text{cor} \\ \vdots \end{bmatrix} & \begin{bmatrix} -\text{syll} \\ -\text{ant} \\ -\text{cor} \\ \vdots \end{bmatrix} \\ \text{b} & \text{a} & \text{ŋ} & \text{k} \end{array}$$

b:
$$\begin{bmatrix} +\text{ant} \\ +\text{cor} \\ +\text{nas} \end{bmatrix} \rightarrow \begin{bmatrix} \alpha\text{ant} \\ \beta\text{cor} \end{bmatrix} \;/\; \text{---} \begin{bmatrix} \alpha\text{ant} \\ \beta\text{cor} \end{bmatrix}$$

In this view there is no relation between the representation of features and the functioning of features in the structural description of phonological rules. Given matrices of the kind given in (1) and a P-rule like (1b), which changes two feature values at the same time, we cannot give a principled account for the absence of P-rules like (2), which involve the same number of features:

(2)
$$\begin{bmatrix} +\text{ant} \\ +\text{cor} \\ +\text{nas} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{nas} \\ +\text{cont} \end{bmatrix} \;/\; \text{---} \begin{bmatrix} -\text{nas} \\ +\text{cont} \end{bmatrix}$$

In addition, by representing assimilation as the change of individual features in a feature matrix, we cannot capture the naturalness of assimilations that involve the 'place-of-articulation' features (cf. 1b above). Given the fact that two features are changed at the same time, one might expect that a rule like (1b) is more complex or marked than a rule which changes only one feature. However, this does not reflect the relative naturalness of 'place-of-articulation' rules and the frequency with which they occur in human languages.[1]

The sounds of a language are taken to be discrete matrices and the P-rules do not change this. Hence, the output of the phonological component is conceived as a string of discrete entities. However, in the actual speech signal it is almost impossible to detect discrete sounds. Under the assumption that the phonological component is input to the phonetic component, we have to assume rules of a very powerful kind, which drastically transform their input segments. We observe that these phonetic interpretation rules replicate the application of earlier P-rules to a large extent. For example, in the word bank the tongue body is not elevated to the velum once for the nasal and once again for the oral stop, as representation (1c) might imply, but it is elevated only once for the whole cluster. Hence, given a representation like (1c) we need phonetic rules that change the discrete matrices of the velar nasal and the velar stop into partially overlapping ones.

For these reasons and many others, the concept of the phonological feature matrix as a bundle of unordered features, as well as the conception of assimilation as a mechanism that copies feature values, has been abandoned. The introduction of autosegmental phonology has changed the view how features and P-rules should be represented. Since Goldsmith (1976), it is widely accepted that features occupy tiers of their own. In addition, since Steriade (1982), P-rules take the form of spreading and/or delinking rules, as exemplified in (3):

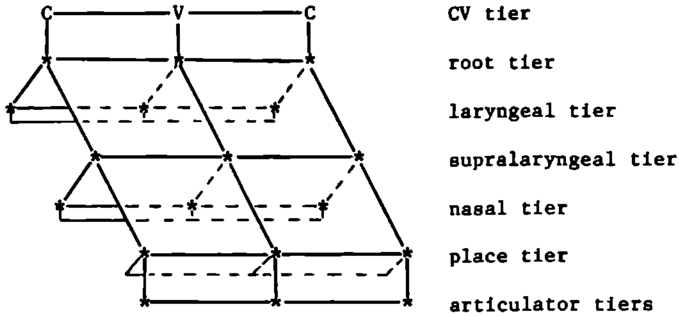
```
(3) a: Spreading          b: Delinking
       [xF] [yF]              [xF]
        |`-._|                 ‡
        X    X                 X
```

In the remainder of this section we will concentrate on the question why the idea that sounds are bundles of unordered features should be relinquished. First of all, we will discuss a proposal according to which features are hierarchically ordered both in underlying and phonetic representation. This static view or template conception is assumed in most recent work on nonlinear phonology, in particular by Clements (1985, 1987a), Sagey (1986a,b), Archangeli and Pulleyblank (1986), and Steriade (1987a,b). Next, we will develop an alternative proposal, continuing earlier work by Wetzels (1985,1986), Hayes (1986b) and De Haas (1987a,b). In the latter view hierarchical representation arises in the course of the derivation by means of a so-called tier decomposition device. It will become clear during the exposition that this dynamic view is superior to the static view in that it covers the facts of the static view, and makes the right predictions with respect to certain possible and impossible rule types.

1.1.1 The static view: Clements (1985,1987a), Sagey (1986b)

Clements (1985) and Sagey (1986b) argue that the universal representation of distinctive features takes the following form:

(4)



This hierarchy entails that various relations exist among particular sets of features. Single features (called terminal nodes) are grouped together under larger nodes or constituents called class nodes.

The proposals by Clements and Sagey differ in details rather than in spirit. Clements assumes that the major class features are gathered together under a special 'manner' node, whereas Sagey assumes that these features are immediately dominated by the root node. A second difference concerns the internal structure of the place node. Clements assumes that the place features fall into two classes, viz. the 'primary' place features [coronal], [anterior] and [distributed] and the 'secondary' place features [high], [low], [back], [round]. Sagey, on the other hand, assumes that the place node is further divided into the articulator nodes 'Labial', 'Coronal' and 'Dorsal' which in turn are anchors for the features [round], [anterior] and [distributed], and [high], [low] and [back], respectively.

The hierarchical ordering is supposed to reflect relationships among sets of features that are justified by phonological processes. "If we find that certain sets of features consistently behave as a unit with respect to certain types of rules of assimilation or resequencing, we have good reason to suppose that they constitute a unit in phonological representation, independently of the actual operation of the rules themselves" (Clements 1985:226). Both Clements and Sagey discuss P-rules that provide evidence for the grouping of features in larger constituents.

Sagey (1986b), and to a lesser extent Clements (1985), adds to this that the representation of features should be grounded on facts of vocal tract anatomy and acoustics. "Humans produce speech using specific articulators in the vocal tract, which produce characteristic effects on the acoustic waveform; the waveform is then perceived and processed by the human auditory system. It would be surprising if this physical mechanism of speech did not influence the structures, representations, processes and segment inventories found in phonology" (Sagey 1986b:17). For example, the grouping of features into the place node is not accidental, but due to the physical mechanisms of speech. "Place features are those features that cause the type of changes in formant structure resulting from changes in the shape of the resonator [=oral tract, WdH], as opposed to nasality, which changes the formants by adding a second resonator, or as opposed to laryngeal features, which don't change the formant shapes at all" (Sagey 1986b:18).

If assimilation is best characterized as autosegmental spreading and if features are hierarchically organized as illustrated in (4), we expect three common types of assimilation, viz. complete assimilation in which the root node is spread, partial assimilation which involves the class nodes, and single-feature assimilation. By assuming that assimilation processes can spread at most one node at a time, an assimilation rule such as the one in (2), or, by the same token, an assimilation rule which spreads [voice] and [anterior] simultaneously, is ruled out, since these features are not immediately dominated by the same class node, and the propagation of these features would require two or more nodes to spread in tandem. Clements (1985:241) therefore concludes that the feature-geometry theory "offers a constrained theory of assimilation processes, according to which all assimilation rules involve the spreading of a single node."

Although this hierarchical representation has many virtues, we will argue that it is inadequate as a model of the representation of distinctive features in underlying representation.

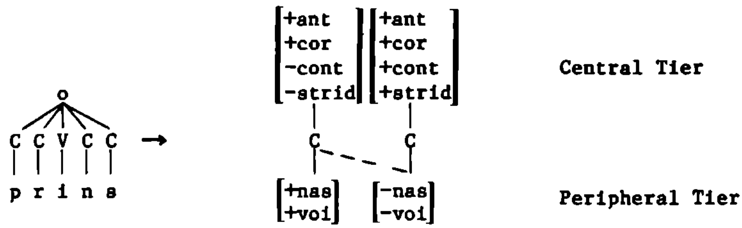
1.1.2 The dynamic view: Tier Decomposition

An alternative theory regarding the representation of features is proposed by Wetzels (1985,1986), Hayes (1986b) and De Haas (1987a,b). These proposals all assume that distinctive features are contained within a nonhierarchically structured matrix. Furthermore, a device of autosegmentalization (Wetzels) or tier decomposition (Hayes) is introduced to give autosegmental status to features or feature complexes in the course of the derivation.

Hayes' (1986b) proposal entails the following. The theory of tier decomposition "...posits only a limited number of tiers in underlying representation, including a CV tier, a unitary melodic tier, and for some languages a tonal tier. The appearance of multiple tiers on the surface is due to rules of tier decomposition, which split up the melody, and thus gradually expand the number of tiers up to the maximum found in phonetic representation. In the process of decomposition the phonology temporally realigns the emerging autosegments. The more noticeable of these realignments are what phonologists write as assimilation rules" (Hayes 1986b:475). More specifically, Hayes assumes that during the phonological derivation the Melodic tier splits up into two subtiers, viz. the Peripheral tier which contains the features [voice], [spread glottis], [nasal]..etc., and the Central tier which contains all manner and place features. Furthermore, he assumes that decomposition cannot take place in one go. At intermediate stages tiers must exist which contain subsets of the full melody, but which are also larger than the very specific tiers that control individual articulators.

Intrusive stop formation in English words like prince, dance etc., extensively discussed in Wetzels (1985), is taken by Hayes as a clear example of Peripheral-tier spreading. A typical derivation would involve tier decomposition and spreading as in (5):

(5)



Wetzels (1986:299) observes that "some features, especially tonal and vowel-harmony features, are more likely to participate in unbounded processes than, say, the features which define the degree of opening. Also, the existence of melodies seems to be restricted to tonal features. The capability of features to express morphological categories points to the same distinction...It seems then that some features more easily than others acquire domains larger than the segment. This might be theoretically interpreted by reserving independent tiers at the underlying level for those features which, in a given language, display typical autosegmental behaviour in the sense discussed above. Local spreading operations can then be taken care of by phonological rules which by convention assign autosegmental status to the features involved and spread them over the domain defined in their structural description." Wetzels furthermore assumes that class features such as 'laryngeal', 'place', 'manner' are not allowed to be part of the phonological representation, although they may occur in phonological rules. The class features are seen as a set of concrete features defined by the theory. If a P-rule refers to such a feature, e.g. 'place' or 'tongue body', the phonological matrix is scanned and the features which are part of their universal definition are turned into autosegmental units, which will link to the same positions to which they were previously attached. Hence, in Wetzels' proposal the device of decomposition is assumed to follow from an interpretation convention of the rule formalism.

Neither proposal provides a well-articulated theory concerning the nature of tier decomposition. Neither do they present crucial empirical or theoretical support for this dynamic view. On the contrary, they admit that the same theoretical results could be obtained under the static view. We will therefore take these proposals for granted and outline a theory of decomposition primarily focusing on the specific details of tier decomposition as a formal device.

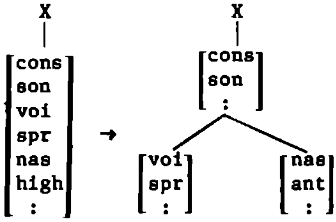
As a point of departure we will take the traditional concept that the sounds of human languages are characterizable as bundles of unordered feature matrices. Together, they represent the phonetic capabilities of man. Features are not abstract entities with an arbitrary definition, but define physical properties and refer to physical domains involved in the process of speech. Features thus have articulatory and/or acoustic correlates: they define the endpoints of a physical scale (+ or -). For example, the features [voice], [spread glottis] and [constricted glottis] refer to particular states of the vocal cords. The feature [voice] defines whether a sound is produced with or without vocal cord vibration; [spread] defines whether a sound is produced with the vocal cords drawn apart or not; and [constricted] defines whether a sound is produced with the vocal cords tightly drawn together or not. Both the number of features and the physical properties and articulators to which they refer are determined by Universal Grammar. Hence, as pointed out by Clements (1985), we do not have to stipulate, time after time, for each individual language that particular sets of features constitute phonological units, since this property is inherent in the universal definition of all individual features. This enables us to leave relations among sets of features undetermined in underlying representation.

The notion of the phonological feature matrix assumed here is very different from the traditional SPE conception. In linear phonology representations are two-dimensional, whereas in nonlinear phonology representations are three-dimensional from the outset. We will assume that the feature matrix is a three-dimensional unit which contains an unordered collection of tiers occupied by single distinctive features. The second difference is of greater importance. In linear phonology all P-rules have access to distinctive features stored within the matrix and may change their value. In our view, however, the individual members of a matrix are inaccessible for assimilatory processes, that is, a matrix is a phonological unit in the strongest possible sense. Assimilation rules do not have access to the whole matrix to change a subset of the features contained within it. Below, we will refer to the feature matrix as the melodic root or shortly root. The melodic root is in many respects comparable to a book with uncut sheets: to make a page accessible it has to be cut.

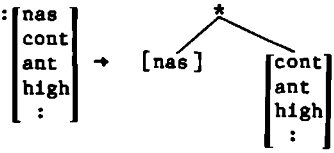
The fact that phonological rules can refer to subclasses of features contained within the melodic root, forces us to posit a mechanism which makes these features available for the usual spreading and delinking rules assumed in autosegmental phonology. We will follow Hayes (1986b) in calling this mechanism tier decomposition. However, unlike Hayes we do not assume that the number of tiers expands in the course of the derivation. We will assume that the number of accessible tiers gradually expands as a consequence of unfolding, resulting in a realignment of tiers previously contained within the phonological matrix. Below, we will go into the nature of decomposition and realignment in considerable detail.

We will try to show that the power added to the grammar by invoking tier decomposition is rather restricted. A small set of universal, intrinsically ordered rewriting rules will be assumed, which gradually expand the number of constituents up to the maximum needed by the phonological and phonetic rules of a language. Phonological processes discussed by Clements (1985, 1987a), Sagey (1986b), and Archangeli and Pulleyblank (1986) point to the following tentative set of decomposition rules:

(6) a.

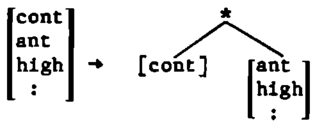


b:

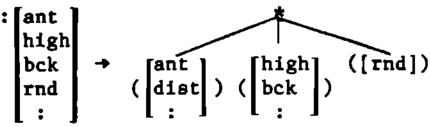


(Root → Laryngeal Supralaryngeal) (Supralaryngeal → Nasal Oral)

c:



d:



(Oral → Degree Place) (Place → Coronal Dorsal Labial)

The class nodes 'Root', 'Laryngeal' and 'Supralaryngeal' have been proposed and motivated in Clements (1985). The 'Nasal', 'Coronal', 'Dorsal' and 'Labial' node have been argued for by Sagey (1986b), and finally the 'Oral' node is introduced in Clements (1987a). We will not reiterate the arguments that have led to the introduction of these class nodes, and refer the interested reader to the cited works for more details. For the purposes of this thesis the total number of intermediate class nodes is not particularly relevant, because we will be concerned primarily with the vocalic features.

The structures in (6) show that all nodes, including the class nodes, constitute feature matrices of their own. After each run the content of the newly derived matrices is smaller than the matrix from which they are derived. Again, we emphasize that the single features contained within these submatrices remain unavailable for spreading and delinking rules. Ultimately, single features can become accessible at the last level of expansion (not given in 7) where the matrices cannot be split up into subconstituents any further, simply because there is only one feature left. In sections 1.1.3.2 and 1.1.3.4, we will discuss the laryngeal and the major class features, respectively, and it will turn out that the features making up these classes remain inaccessible for assimilatory processes in the phonological component. As a consequence, the last step of expansion will be limited to particular feature classes.

The geometry which arises by means of the rules in (6) departs from those previously proposed in a number of respects. First, Clements (1985) assumes that individual features are the terminal nodes which are organized under hierarchically superordinate nodes, where the latter themselves are abstract non-terminal nodes devoid of phonetic content. In our proposal, on the other hand, class nodes constitute individual feature matrices, and these class nodes can be the terminal nodes in the geometry. Second, Sagey (1986b:47-48) arbitrarily assumes that the feature [nasal] is organized under the 'soft palate' node. As a result, she allows for two distinct types of assimilation rules, viz. rules which involve the 'soft palate' node, and rules which involve the [nasal] node. However, she admits that crucial empirical evidence supporting this claim is absent. In our proposal the distinction between the 'soft palate' node and the [nasal] node is superfluous, since the application of rule (6b) will make the [nasal] feature accessible; therefore there is no need for additional unfolding having the redundant effect of rendering the [nasal] feature accessible. Finally, the present theory departs from the previous ones in that we will assume that all major class features (henceforth MCFs) remain within the melodic root. This aspect of the representation is suggested in Schein and Steriade (1986), and will be motivated in section 1.1.3.4. below. We will show that this representation of the MCFs allows us to account for three asymmetries between the major and non-major class features.

This discussion clearly raises the interesting question of where tier decomposition takes place. At least two options seem to be available: (i) the unfolding takes place in a separate phrase structure component, and (ii) the tier decomposition rules and P-rules apply in the same component. As a starting point, we will take the second option in which both rule types interact.

Suppose a hypothetical language NL, the grammar of which contains a P-rule P_n that renders a sequence of sounds homorganic with respect to the place-of-articulation features, and is the first rule to refer to place. In underlying representation these features are stored within the melodic root, and thus inaccessible for P_n. In one way or an other these features must become accessible. For the proper application of P_n the decomposition rules (6a) through (6c) have to apply first. Wetzels (1986) therefore assumes an interpretation convention of the rule formalism. In this thesis, we will approach the relationship between the tier decomposition rules and the normal phonological rules from a different perspective, and propose the universal Tier Decomposition Convention in (7) as an organizing principle of phonological theory:

(7) Tier Decomposition Convention (TDC)
A tier decomposition rule T that makes the (class) node F accessible is immediately ordered prior to the first P-rule referring to this node F in its structural description.

Given the TDC in (7), the decomposition rule (6c) will be ordered immediately before P_n. Furthermore, the intrinsic ordering of the tier decomposition rules will ensure that the rules in (6a) and (6b) are ordered before P_n as well. Although the TDC orders (6c) immediately before P_n, this does not imply that (6a, b) apply immediately before (6c). Hence, the TDC does not allow for a phonological rule P_m which applies in between (6c) and P_n, but it does not rule out the ordering of P_m immediately before (6c).

We will now take into consideration an interesting aspect of the TDC which extends far beyond the simple ordering relation established above. Phonological theory allows for several types of ordering relations between P-rules. First, in recent literature (cf. Kiparsky 1982, 1985, Booij and Rubach 1987, among others) a distinction is made between cyclic rules, postcyclic rules, and postlexical rules. The ordering of these subtypes is intrinsically determined by the organization of the phonological component (we will return to this issue in section 1.4, where we discuss the main principles of Lexical Phonology). For each of these three rule types, P-rules will be intrinsically ordered, extrinsically ordered, or unordered. Here, we will be concerned with the latter situation, and we will argue that our tier decomposition theory eliminates a kind of indeterminacy on the level of phonological theory itself. If two rules A and B are unordered with respect to each other, and if a rule C exists that is crucially ordered after both A and B, the same set of facts can be derived in three different ways: (i) A is ordered before B and B before C, (ii) B is ordered before A, and A before C, and (iii) A and B apply simultaneously before C. To put it in formal terms, a given language having n unordered rules in its grammar can be accounted for by the number of factorial n plus 1 equally simple grammars (i.e. n!+1).

A particularly striking observation concerns rules that involve different articulators (e.g. the larynx, the soft palate, the tongue body..etc.). These rules are characteristic examples of rules which are unordered with respect to each other. It will turn out that these rules are not unordered in the theory advanced, but that instead, their relative ordering is determined by the organization of the theory. Suppose our hypothetical language NL has in its grammar a second rule P_m invoking the laryngeal features. P_n and P_m refer to different articulators which implies that these rules are unordered. The TDC will bring about an intrinsic ordering, since it will order P_m immediately after tier decomposition rule (6a), while it will order P_n immediately after (6c). As a result, P_m will be intrinsically ordered prior to P_n, since the tier decomposition rules are intrinsically ordered, and apply top to bottom. In conclusion, our tier decomposition theory resolves the indeterminacy problem, characteristic of previous analyses. Furthermore, if it is correct that linguistic theory is a reflection of the speaker's competence, the theory allowing for the smallest number of grammars accounting for the same set of data should be preferred. In this respect, the tier decomposition theory is superior to all previous ones, including the theory proposed by Clements (1985) and Sagey (1986b).

A point similar to the above is made in Hayes (1986b) for the Austronesian language Toba Batak spoken in northern Sumatra. He discusses four assimilation rules, some of which have to be extrinsically ordered. In (8) some relevant forms are given, showing the changes accomplished by these processes:

(8) a: /n/-Assimilation:

maŋan baoa an	~	maŋabbaoa an	'that man is eating'
lɛan lali	~	lɛallali	'give a hen-harrier'

b: Denasalization:

maŋinum tuak	~	maŋinuptuak	'drink palm wine'
manaŋ pulpen	~	manakpulpen	'or a pen'

c: /h/-Assimilation:

marisap hita	~	marisappita	'let us smoke'
dɔhɔt halak	~	dɔhɔttalak	'and a person'

d: Glottal Formation:

ganup taɔn	~	ganu?taɔn	'every year'
halak batak	~	hala?batak	'Batak person'

In any account, /n/-Assimilation must precede Denasalization, since otherwise it would be bled in cases like /np/ → [pp] (not *[tp]). Denasalization in turn must precede /h/-Assimilation, since the latter is triggered by obstruents including those created by Denasalization (e.g. /mh/ → //ph// → [pp]). Finally, Glottal Formation must take place after these three rules, since it is bled by the application of at least one of these rules. In short, in previous analyses these four rules must be extrinsically ordered. It can be shown, however, that the ordering of /n/-Assimilation before the other rules need not be stipulated, since its early application is expected under the theory proposed. The rule of /n/-Assimilation is a complete assimilation or gemination rule and applies to the melodic root as a whole. The other rules are partial assimilation rules, and they require decomposition. Hayes (1986b:483) notes that the required ordering of complete assimilation before partial assimilation follows from the organization of the theory: earlier rules expect less fully decomposed representations. We thus do not need to stipulate the ordering of /n/-Assimilation before the other rules explicitly. This is not to say that the opposite ordering, i.e. partial assimilation before complete assimilation, is excluded. The theory permits such an ordering relation, although it puts a severe constraint on it, because the application of a complete assimilation rule can only follow a partial assimilation rule if the former applies in later subcomponent. To be more specific, the ordering of total assimilation after partial assimilation is allowed, if the latter is a lexical, and the former a post-lexical rule. If both rules are post-lexical, we expect the ordering to be as in Toba Batak. At present, we have not been able to verify this implication of our theory, and leave this as a point for future research. One thing must be clear, though: the order in which the total and partial assimilation rules of Toba Batak apply is expected under our theory. In the static view, on the other hand, one is obliged to stipulate the ordering of complete assimilation before partial assimilation, and we will take this as a further point in favor of the dynamic view.

In summary, in our approach we start out with a phonological feature matrix that resembles a book with uncut sheets. Subsequently, this representation is unfolded by the universal rules of tier decomposition which are associated with the language-specific P-rules by the universal Tier Decomposition Convention. The ultimate result is a representation which resembles a cut and glued paper construction, as argued for by

Clements and Sagey. Before we take up the task of motivating the concept of tier decomposition in the next section, the dynamic view will be demonstrated in full swing.

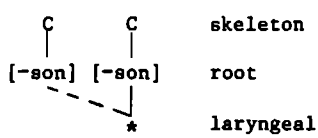
Let us take a look at two well-known rules of Dutch, viz. Regressive Voicing Assimilation and Nasal Assimilation. This exposition will also enable us to go into the rule formalism adopted in this thesis.

In Dutch, obstruent clusters always agree in voice. If the rightmost obstruent is a plosive, all preceding obstruents adopt the feature [voice] from this stop, as is illustrated in (9):

(9)	ko[bd]uel	'heading duel'	vs.	koppen	'heads'
	kra[pk]ocktail	'crab cocktail'		krabben	'crabs'
	ka[zb]oek	'cash-book'		kasontvangst	'cash receipt'
	kaa[sp]ers	'cheese-press'		kazen	'cheeses'
	la[vb]ek	'coward'		laffe	'spineless'
	lij[ft]tocht	'subsistence'		lijven	'bodies'

The rule that accounts for these forms is formalized in (10):

(10) Regressive Voicing Assimilation:



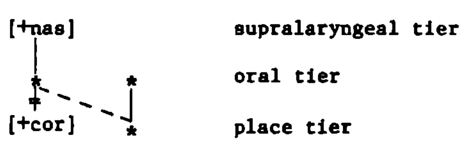
The second rule, which Dutch shares with many languages, is nasal assimilation. An underlying /n/ receives the place features from a following consonant:

(11)

a: lamp	'lamp'	b: inpakken	'pack'	c: in bad	'in bath'	[mb]
franje	'fringe'	injectie	'injection'	in juni	'in June'	[ɲj]
slank	'slender'	inkopen	'purchase'	in kas	'in cash'	[ŋk]
pinda	'peanut'	intomen	'kerb'	in tranen	'in tears'	[nt]

The rule responsible for the changes in (11) can be stated as follows:

(12) Nasal Assimilation:



The rule formalism is the one adopted in autosegmental phonology. The structural description of a rule is indicated by the uninterrupted association lines between the relevant levels of the representation, while the structural change is considered as the spreading - indicated by the dotted line - of a node to an adjacent segment. In addition, we assume the abbreviatory convention proposed by Clements (1985:249-250), and reproduced in (13):

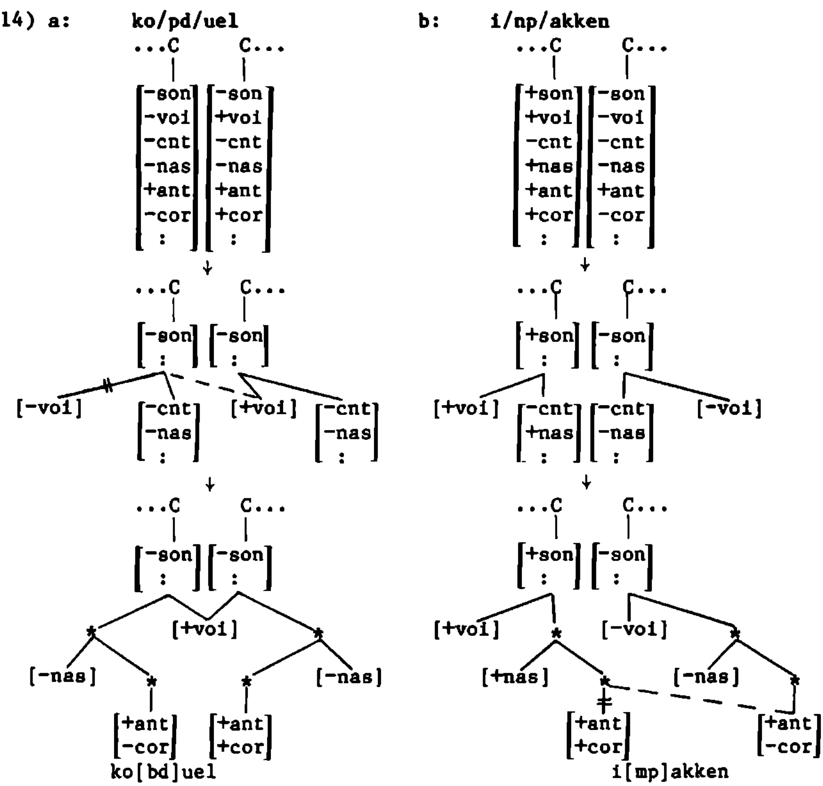
(13) "Given a configuration of type (iii) occurring as a subpart of a phonological representation K, where S is a class tier, T is any tier adjacent to S, and the n are nodes of any appropriate type, (iii) satisfies (iv), a subpart of some structural description SD of a rule R, only if node n(S) in (iii) dominates [αF] (where α is + or −):

(iii) tier S: n | tier T: n   (iv) tier S: [αF] | tier T n

Under this convention, "[αF]" in (iv) designates a class tier node n(S), not a feature [αF], and is to be understood as a condition placed upon the node n(S) in (iii) being tested as a possible match for n(S) in (iv), requiring it to dominate the feature [αF] in K."

According to convention (14) [+nas] in (13) designates the supralaryngeal node which must dominate the feature [+nas]. The rule will take effect if and only if the representation fulfills this requirement.

In (14) below the relevant parts of the derivations of kopduel and inpakken are given:

(14)


The rules of Regressive Voicing Assimilation and Nasal Assimilation are not crucially ordered with respect to each other. Instead, the mode of tier decomposition determines the order in which these rules apply.

1.1.3 A comparison: static or dynamic feature representation

The output of the tier decomposition rules in (6) resembles the feature geometries proposed by Clements (1985, 1987a) and Sagey (1986b) in many respects. They differ in the way features are organized in underlying representation. In this subsection we will bring forward several arguments against the static view. We have already anticipated one of these arguments in the previous section.

The first argument concerns the ordering of P-rules. We have observed that rules referring to different articulators are generally assumed to be unordered with respect to each other. We have noted that the existence of unordered rules causes phonological theory to be faced with a kind of indeterminacy. If a given language has n unordered rules, phonological theory allows for factorial-n plus 1 equivalent grammars to account for this language. The theory of tier decomposition resolves this indeterminacy problem straightforwardly, since the rules that involve different articulators are intrinsically ordered as a consequence of the universal Tier Decomposition Convention (7), and the intrinsically ordered decomposition rules (6). Hence, the indeterminacy problem disappears, since the theory determines that of the n!+1 possible grammars only the one which follows from the TDC is sustained. Furthermore, we have shown that particular extrinsic ordering relations, viz. those which reflect the mode of decomposition in (6), do not have to be stipulated as such. For example, in Toba Batak, the order in which the rule of /n/-Assimilation on the one hand, and the rules of Denasalization, /h/-Assimilation and Glottal Formation on the other, apply, does not have to be stipulated, since the former is a complete assimilation rule, which expects less-decomposed structure, and the latter are partial assimilation rules which require some decomposition. Under the static conception, the ordering of the complete assimilation rule before the partial ones cannot be derived from the organization of the grammar, and therefore must be stipulated. From this discussion, we can conclude that the dynamic conception is superior to the static one, because it enables us to reduce the number of ordering stipulations.

Wetzels (1986:299) and Hayes (1986b:493ff.) present a further theory-internal argument in favor of tier decomposition based on the Obligatory Contour Principle (OCP). The OCP is a universal constraint which rules out sequences of identical melodic autosegments within the underlying representation of a morpheme. On the assumption that melodic subtiers do exist in underlying forms, one might expect that the OCP would hold for the melodic root as well as the subordinate tiers. Hayes shows for the Toba Batak data that the OCP cannot hold for the subtiers. Otherwise, the difference between the forms in (15) could not be derived from the Linking Constraint (cf. Hayes 1986a,b, and section 1.3. below). This constraint states that association lines mentioned in the SD of a

P-rule must be interpreted as exhaustive:

(15) a: holom saɔtik ~ holopsaɔtik -/→ *holoʔsaɔtik 'somewhat dark'
manaŋ pulpen ~ manakpulpen -/→ *manaʔpulpen 'or a pen'
b: saksaŋ → saʔsaŋ 'ceremonial dish'
pɛkpɛŋ → pɛʔpɛŋ 'midget'

The forms in (15a) undergo Denasalization and as a result shared matrices are created for the Peripheral features. In the static view two underlying representations for /pɛkpɛŋ/ are foreseeable, viz. one which is in conformity with the OCP and one which is not. For the representation in accordance with the OCP the Peripheral features merge, since they are identical for both /k/ and /p/.

Hayes argues that the OCP must hold in underlying representation to account for the absence of Glottal Formation (GF) in true geminates like pittu 'door', lɔppa 'cook' and dɛkkɛ 'fish'. If true geminates are represented with doubly-linked matrices, the absence of GF follows from the Linking Constraint, since such structures are immune to GF. By the same token, the absence of GF in (15a) can also be derived from this constraint, since Denasalization creates the doubly-linked structure. However, if the OCP has access to subtiers, an account based on the Linking Constraint would become untenable, since in that case the OCP would create the shared matrices and it would be impossible to discriminate between underlying /kp/ and derived /kp/. Hence, the static view seems to require a restriction on the lexical application of the OCP to the effect that subtiers are excluded from undergoing this convention. Under tier decomposition this problem does not arise, since in the lexical representation of the forms in (15b) we have two unsplit and distinct matrices which do not fulfill the requirements of the OCP.

This argument is highly theory-internal, and hinges on the assumption that the OCP is restricted to underlying representations, since tier decomposition will result in representations virtually identical to the ones assumed by Clements (1985) and Sagey (1986b). If it should turn out that the OCP holds for all stages in the derivation, and if, additionally, subtiers are exempted from the OCP at all these stages, the advantage of the tier decomposition theory as opposed to Clements' (1985) proposal vanishes almost entirely, because then a similar restriction on the OCP must be added. Moreover, Odden (1986a) presents several arguments against the OCP as a universal principle. From his discussion it is clear that languages differ in the way they incorporate the OCP (in Odden's view a general cognitive strategy). In some languages this principle is restricted to lexical representations; in others it is restricted to derived representations; and in others again it holds for both. Hence, this OCP argument presented by Hayes (1986b) stands or falls with the claim that the OCP is restricted to underlying representations. As far as we can see, the examples discussed by Odden (1986a), which are all based on tonal phenomena, do not refute this claim if we assume, as we did, that the tonal features are arrayed on a plane different from the melody.

Below, we will present several empirical arguments in favor of the dynamic decomposition approach. Most of the arguments are concerned with the accessibility of features. In the static approach exemplified in (4) all individual features occupy separate tiers, that is, all features are constituents. These smallest units are gathered into larger units. One prediction is that the spreading or transposition of single features is just as simple or marked as the spreading or transposition of larger constituents. Below, we will argue that this prediction is incorrect. It will turn out that the dynamic view enables us to explain the absence of particular rule types, because there is a stage in the derivation in which features are contained in larger constituents or feature matrices.

1.1.3.1 **Two types of P-rules**

Given the assumption that distinctive features are contained within single phonological matrices in underlying representation, and given the further assumption that features become accessible for assimilatory processes by means of tier decomposition, we expect to find two types of P-rules: (i) P-rules that trigger decomposition, and that take the form of spreading operations, and (ii) P-rules that do not activate decomposition, and that take the form of linear feature-filling or feature-changing lexical redundancy rules. The two types are represented schematically in (16):

```
(16) a:  X      X          b:  X     X          X      X
         |      |              |     |          |      |
        [aF]  [-aF]          [aF]  [bG]  -->  [-aF]  [bG]
```

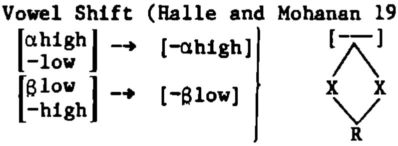
Mascaro (1986) observes that the genuine autosegmental operations of spreading, association and deassociation are still allowed to mix freely with the linear type of rule formalism proposed by SPE. His aim is to reduce cases of apparently segmental operations to the constrained autosegmental formalism, and to eliminate or at least isolate the segmental residue. We will argue, conversely, that the distinction between the rule types in (16) proves to be empirically motivated. As Leo Wetzels (personal communication) has suggested, the different rule types exemplified in (16) may reflect a basic division among (lexical) phonological processes. The rule type of (16a) would represent the truly generative processes, while the one in (16b) would be used to account for highly morphologized or fossilized phonological alternations which are deeply embedded in the lexicon. We will clarify this point for a well-known example from English.

Halle and Mohanan (1985) present an elaborate description of the segmental phonology of Modern English. Below, we will concentrate on a small subset of the lexical rules they propose: those that provide crucial evidence for the distinction drawn in (16). The forms in (17) reveal that rules affecting the quantity of vowels go together with processes of Vowel Shift and Diphthongization:

(17) a:	divine	- divinity	(ay-ɪ)	b:	manager	managerial
	serene	- serenity	(iy-ɛ)		marginal	marginalia
	sane	- sanity	(ey-æ)		Lilliput	Lilliputian
	profound	- profundity	(aw-ʌ)		algebra	algebraic
	assume	- assumption	(uw-ʌ)		ambiguous	ambiguity

Halle and Mohanan (1985:77-78) propose the rules of Shortening and CiV-Lengthening to account for the quantitative alternations taking place in the examples of (17). Furthermore, they assume, following SPE, that the grammar contains rules affecting the quality of long vowels. They propose to derive the complex surface vowels [ay, iy, ey, uw] by a rule of Vowel Shift and a rule of Diphthongization from the underlying vowels /Ī, ē, ā , ō/. Their formalization of Vowel Shift is reproduced in (18):

(18) Vowel Shift (Halle and Mohanan 1985:78)

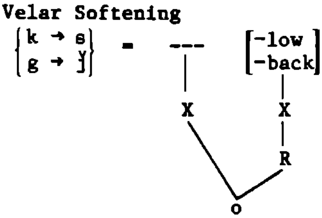


They furthermore argue that the facts of Velar Softening illustrated in (19) provide additional support for recognizing Vowel Shift as a synchronic rule of English, because, if Velar Softening is ordered before Vowel Shift, the context in which the former rule applies can be stated in a relatively simple way:

(19) a:	critic	- criticize	(k-s)	b:	fungus	- fungi	(g-ǰ)
	medicate	- medicine			analogue	- analogy/analogize	
	matrix	- matrices			larynx	- laryngeal	

Before Vowel Shift takes place the suffix vowels inducing Velar Softening all share the features [-back, -low]. On the basis of this observation, Halle and Mohanan decide to adopt the following semi-formal description of this process:

(20) Velar Softening



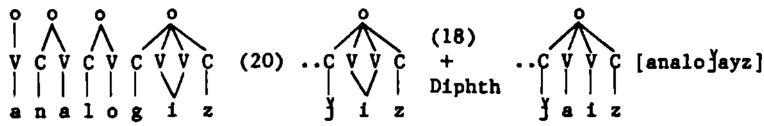
Although the authors do not go into a distinctive feature definition of the structural change of the rule, it appears that at least the features [coronal], [anterior], [high], [back], and [continuant] are affected. In the preceding section, we discussed one of the main virtues of feature geometry, viz. that it enables us to impose severe restrictions on assimilatory processes. Clements (1985) notes that assimilation rules, i.e. spreading rules, can only involve a single node in the feature geometry. The changes accomplished by Velar Softening do not obey this requirement, however, since several nodes spread simultaneously. If, with regard to spreading operations, we want to adhere to the strong claim, we could conclude that Velar Softening is a rule which does not involve feature spreading, but is rather a feature-changing operation that is active at a deep level in the lexicon. Kiparsky (1982:34) observes the following with regard to the status of Velar Softening: "the [s] in criticize is derived from /k/ by a "Velar Softening" rule, which applies throughout the derivational ("Romance") vocabulary of English, and accounts here for the regular relationship between criticize, criticism and critic, critical. This does not imply that the speaker or hearer need in any way mentally "derive" the words he says or hears by means of such rules as Velar Softening. What it does mean is that the alternations they govern belong to the regular phonological pattern of English...The claim made is that someone who knows English implicitly knows that pattern, and will under appropriate circumstances recognize the difference between regular and irregular alternations, though he may not be able, even after reflection, to verbalize the rules that underlie it." We will argue that the tier decomposition theory advanced here makes possible a formal distinction between truly assimilatory processes and processes such as Velar Softening.

The litmos test for determining whether Velar Softening is a spreading rule or a feature-changing rule is based upon the Linking Constraint proposed by Hayes (1986a) (cf. section 1.3 below). The Linking Constraint states that a phonological rule P will apply to a representation R, if and only if the association lines in the structural description of P exhaustively match those of R. In other words, if rule P refers to the autosegmental levels A and B, where A and B are connected by one association line, P will apply to representation R, if A is uniquely linked to B, and vice versa.

We will demonstrate that the formalization of Velar Softening as a spreading operation incorrectly blocks Vowel Shift. The alternation between /g/ and /ǰ/ in the pair analogue - analogize indicates that at least the height features spread from the suffix vowel to the stem-final /g/. As a result, the height features will be linked to the stem-final consonant as well as to the suffix vowel. When Vowel Shift arrives, the Linking Constraint will block its application to the output of Velar Softening, since the height features referred to in the structural description of Vowel Shift are not exclusively associated to the rime node, as is shown in the partial derivation given in (21):

```
(21) o  o   o     o               C  V V
     |  /\  /\   //\\             |  \/
     V C V C V C V V C   (20)     *   *    (18) blocked  *[analoǰīz]
     | | | | | |  \/ |            |\  |
     a n a l o g  i  z            g  +h
                                     -l
```

Hence, by assuming that Velar Softening involves feature spreading, the fact that the triggering vowel may undergo subsequent Vowel Shift cannot be accounted for. If, on the other hand, we assume that this process is a feature-copy rule that does not create shared matrices between the trigger and the target, the Linking Constraint will not block the application of Vowel Shift:

(22)


The Linking Constraint enables us to make a principled decision with respect to the status of Velar Softening in the grammar of contemporary English. It cannot take the form of a spreading rule, since in that case the Linking Constraint would prevent subsequent Vowel Shift. In addition, we do not have to mark Velar Softening as a feature-changing rule, as the features in the structural description do not constitute a unit in the feature geometry, and hence the universal tier decomposition rules in (6) will not be activated. The theory advanced presupposes a stage in the derivation where all distinctive features are contained within a single matrix, and this assumption gives us the opportunity to change features by copying rules which do not affect the unitary status of the matrix.

In conclusion, the existence of two formally different rule types, viz. P-rules which trigger tier decomposition versus P-rules that do not exhibit this property, provides crucial empirical support for a mode of tier decomposition in phonological theory. Without such a device, ad hoc stipulations are necessary to obtain the same results. Furthermore, the intuitively correct distinction between the truly generative P-rules, and the lexical redundancy rules which merely express the speaker's knowledge of a morphologized pattern, can be captured formally by using two different rule types.

1.1.3.2 Single-feature assimilation

Clements (1985) notes that evidence for single-feature assimilation, outside tone phonology, is scarce. Given the geometry, this result is somewhat surprising, since class-node assimilation and single-feature assimilation should be equally marked. Below, it will become apparent that these two types of assimilation are in fact not equally marked, and thet class-node assimilation is far more natural than single-feature assimilation. We will illustrate this point for a set of rules that refer to the laryngeal features in Late Vedic and Classical Sanskrit. The interaction of these processes has concerned many linguists since Whitney (1889) (cf. Zwicky 1965, Anderson 1970, Sag 1974, 1976, Phelps 1975a and Schindler 1976). It is not our purpose to give a full-fledged analysis of all the Sanskrit facts, and for more details the reader is referred to the works cited, especially Sag's and Schindler's. The analysis presented below is in many respects a nonlinear formalization of their ideas.

Sanskrit has a consonant system in which the features [voice] and [spread] both are distinctive. The relevant part of the consonant inventory is given in (23):

(23) Sanskrit plain stops

	p	ph	b	bh	t	th	d	dh	k	kh	g	gh
[voice]	-	-	+	+	-	-	+	+	-	-	+	+
[spread]	-	+	-	+	-	+	-	+	-	+	-	+
'Place'	P	P	P	P	T	T	T	T	K	K	K	K[2]

Let us first take a look at the alternations involving aspiration in (24).[3]

(24) bōdhati 'he knows' (cf. tap+a+ti 'he heats')
bhōtsyati 'he will know' (cf. tap+sya+ti 'he will heat')
buddha 'known' (cf. tap+ta 'heating')
bubōdha 'he has known' (cf. ta+tāp+ta 'he has heated')

With regard to these data, the discussion up to the present day has focused on the underlying form of the root 'to know'. Zwicky (1965), Anderson (1970) and Phelps (1975a) have assumed /bhudh-/ and a rule of aspiration dissimilation commonly referred to as Grassmann's Law. Others, following Pānini and Whitney (1889) take /budh-/ as the underlying form and a rule of 'aspiration throw back'. We agree with Sag and Schindler that the former account, which assumes that Grassmann's Law was a synchronic rule of Classical Sanskrit, is untenable (cf. De Haas (1988b) for a detailed discussion).

The first phonological process of interest to us is the rule of Final Strengthening, which devoices and deaspirates a word-final obstruent:

(25)

accusative	nominative	gloss
pādam	pāt	'foot'
marutam	marut	'wind, wind-god'
budham	bhut	'awakening'
patham	pat	'road'

These alternations can be accounted for by the process stated in (26) below, if we assume that the unmarked values [-voice] and [-spread] are filled in later in the derivation by a set of redundancy rules:

(26) Final Strengthening (FS)

C# skeleton
|
[-son] root tier
‡
* laryngeal tier

Besides this final strengthening rule, clusters of two obstruents undergo laryngeal assimilation. In general, roots ending in a voiced aspirated obstruent, which precede suffixes begining with /t, th, h/, trigger progressive assimilation (Bartholomae's Law), whereas all other clusters undergo regressive assimilation, as is shown in (27):

(27) a:

acc.sg.	instr.pl.	loc.pl.	
marut+am	marud+bhis	marut+su	'wind'
pād+am	pad+bhis	pat+su	'foot'
budh+am	bhud+bhis	bhut+su	'awakening'
stubh+am	stub+bhis	stup+su	'praising'

b:

tap+a+ti	'he heats'	tap+sya+ti	'he will heat'
bōdh+a+ti	'he knows'	bhōt+sya+ti	'he will know'
ruṇadh+mi	'I obstruct'	ruṇat+ṣi	'you obstruct'

c:

tap+a+ti	tap+ta	'heating'	
bōdh+a+ti	bud+dha	'known'	
ruṇadh+mi	rund+dhas	'know'(2.dual)	(cf. kuru+thas 'make')
labh+a+te	lab+dhas	'take'(2.dual)	

The following set of rules accounts for the alternations above:

(28) a: Regressive Larynx Assimilation (RLA)

C C skeleton

[-son] [-son] root tier

$\neq$

* * laryngeal tier

b: Bartholomae's Law (BL)

C C_1 skeleton where C_1 is /t, th, h/

[-son] [-son]

$\neq$

[+voi, +spr] *

c: Aspiration Throw Back (AT)

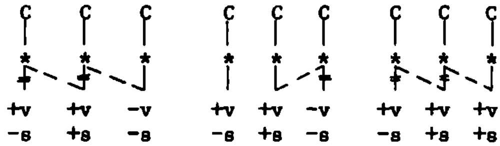
ROOT[C where [ ]' indicates a floating node.

[-son] root tier

[+vce, +spr]' laryngeal tier

Below, we present some sample derivations. In these derivations a rule of cluster deaspiration is left out of consideration. This rule deaspirates the left-hand member of an aspirated consonant cluster, e.g. it changes /dhbh/ into [dbh]. We will assume that cluster deaspiration takes place in the phonetic component, where unpronounceable outputs of the phonological component are automatically corrected by a system of phonetic rules that turn phonological structures into articulatory movements. This is essentially the position taken by Hermans (1985:248) for deaspiration in Icelandic.

(29) /baudh+sya+ti/ /budh+ta/ /budh bhis/



(RLA + AT)	(BL)	(FDD +RLA + AT)
au → ō	dhdh → ddh	dhbh → dbh
bhōtsyati	buddha	bhudbhis

The discussion above shows that the Sanskrit facts find a rather straightforward explanation within autosegmental phonology irrespective of the geometry assumed. However, the problem is not the proper description of the Sanskrit facts, it is how to account for the nonoccurrence of languages that are similar to Sanskrit, but in which (i) voicing assimilation takes place without affecting the feature [spread], or (ii) aspiration assimilation occurs independently of the voice specification:

(30) a: Sanskrit	b: *Sanskrit (i)	c: *Sanskrit (ii)
bh+t → bhdh	bh+t → bhd	bh+t → bhth
p+dh → bhdh	p+dh → bdh	p+dh → phdh
ph+d → bd	ph+d → bhd	ph+d → pd
dh+s → ts	dh+s → ths	dh+s → dhs

The geometry given in (4) does not provide a principled way for excluding unattested distributional patterns as exemplified in (30b, c). Additional mechanisms must be invoked to rule out single-feature assimilations of this type. Thus, although the hierarchical ordering of features limits the amount of possible assimilation rules in a nontrivial sense, it is still too powerful in that it allows for processes that are absent in the languages of the world.

In the theory of tier decomposition the asymmetry in (30) is to be expected. Recall that we have assumed that all nodes, including class nodes such as 'Laryngeal', are matrices which contain phonological features. The features contained within these matrices define the articulator involved. For example, tier decomposition rule (6a) subdivides the melodic root into three distinct feature matrices, viz. the root which contains the MCFs, the laryngeal node which contains the features [voice], [spread] and [constricted], and the supralaryngeal node which contains all remaining features. Additional decomposition is necessary to make features contained within these submatrices accessible for assimilatory processes. The absence of the assimilation processes exemplified in (31b, c) makes it clear that the laryngeal node cannot be subdivided any further, and that the laryngeal node itself will be the terminal node in the geometry. This discussion reveals an important difference between our dynamic view of feature representation and the static conception of Clements (1985) and Sagey (1986b). They assume that individual features are the terminal nodes in the geometry. The features are hierarchically organized under non-terminal class nodes which are themselves devoid of phonetic content. In our conception class nodes are not abstract entities, but feature matrices. The nonoccurrence of assimilation processes like (30b, c) provides strong evidence for our interpretation of the notion of class node.

1.1.3.3 Rules of Transposition

A third point in favor of the theory advocated here concerns so-called rules of transposition. This notion will be used in its broadest sense, in which it includes metathesis rules, word games and speech errors. We will discuss these three subtypes together, since they share essentially the same property, that of metathesizing two segments.

Metathesis is examined as a more or less systematic phenomenon by Ultan (1971), who presents many different types. The theory of autosegmental phonology allows us to show that many changes that previously led phonologists to posit a rule of metathesis can be accounted for without positing permutation transformations. One clear example of this is the rule of Aspiration Throw Back in Classical Sanskrit (cf. 1.1.3.2). However, many examples of metathesis remain that provide evidence for the permutation of sounds as a possible rule type. In (31) below, a few examples are given that illustrate the necessity of this formal enrichment:

(31) a: Kasem (cf. Phelps 1975b, 1979, De Haas 1988a)

singular	plural	
tasug-u	tasu-du (←tasug-du)	'granary cover'
bolo (←bola-u)	bwālu (←boal-du)	'valley'
fogo (←foga-u)	fwadu (←foag-du)	'die, dice'

b: Rotuman (cf. Churchward 1940, McCarthy 1986)

complete phase	incomplete phase	
pure	pṷer	'to decide'
tiko	ti̭ok	'flesh'
pepa	pḙap	'paper'

c: Cornish (cf. Ultan 1971)

whẹlth (sg.) whethlow (pl.) 'narration'

d: Lithuanian (cf. Ultan 1971)

drẽks	(fut.)	drẽskia	(3.sg.pres.)	'to tear'
reikšti	(infin.)	reiške	(3.sg.pret.)	'to mean'

e: Sierra Miwok (cf. Smith and Hermans 1982, Smith 1985)

hüleet	'to fly'	hülte-jee-nü	'to hop'
?ünüü-pa	'come to one'	?ünpü-j-nü	'will come to one'
massokka	'five'	masko-ppa	'five at a time'

One clear generalization emerges from the metathesis facts above, that is, permutation always involves segments. Metatheses of subordinate nodes such as 'place', or of single features such as [continuant] do not occur. For example, we do find permutations of the type wasp → waps, but we do not find wasp → *waft or *watf. It is the task of linguistic theory to constrain the notational system so that metatheses of the latter type are systematically excluded.

Word games constitute the second type of transposition. The data below show that even in word games permutation is confined to segments.

(32) a: Bedouin Hijazi Arabic (cf. McCarthy 1982)

base form		game form
kattab	'write'	battak, takkab, tabbak, bakkat, kabbat
?arsal	'seat'	?aslar, ?asral, ?alsar, ?arlas, ?alras

b: Hanunoo (Philippine language, cf. McCarthy 1982)

rignuk	'tame'	nugrik
?usah	'one'	sa?uh

c: Korean (cf. Sohn 1987)

hobak	'pumpkin'	habok
bica	'visa'	baci

d: LuGanda (cf. Clements 1986a)

kimuli	'flower'	limuki
mukono	'arm'	nokomu
jjuba	'dove'	bbaju

Shattuck-Hufnagel and Klatt (1979), among others, seek to analyze the third subtype, i.e. substitution and exchange errors in actual speech, in a systematic way. They ask the question "whether the psychological representation of words is in terms of phonetic segments and their component distinctive features during the sentence planning" (p.44). Their analysis of the speech errors shows that in the course of the sentence planning, when speech errors are introduced, segments are independently movable, whereas features or feature complexes are not. For example, exchange errors such as motato for tomato are very common, whereas renditions as ponato for tomato are negligible in number.[4]

From this we must conclude that features and subtiers are not independently movable entities at the level where permutation takes place. In the theory we are proposing, such a level exists, viz. underlying representation. In the tree approach, on the other hand, no such level is available. Hence, additional devices must be introduced to constrain the theory in such a way that it allows for segment permutation, while it blocks intrasegmental permutations.

The claim that rules of transposition take underlying forms as their input implies that genuine P-rules take the transposed form as input. The following example mentioned in Campbell (1980) shows that the output of a Finnish word game, in which the first consonant and vowel of a succeeding pair of words are interchanged, is input to the vowel harmony rule:

(33) a: saksalaisia hätüütettin 'the Germans were attacked'
häksäläisiä satuutettin/ *häksalaisia satüütettin

b: tükkään urheilusta 'I like sports'
ukkaan türheilüstä/ *ukkään türheilusta

The Chinese secret language facts reported in Yip (1982) also support our claim.[5] The forms to the left of the arrow in (34) show the Peking Mandarin forms, and those to the right are the May-ka secret language equivalents:

(34) pêý → pâý kẽ̋y (tone sandhi) pā̋y kêý
çyέń → çyâý kyέń (vowel merger) çŷέ kyέń (pal.) çŷέ tçyέń
káẃ → kâý káẃ (dissimilation) kā̋y láẃ

A number of P-rules apply to the output of this secret language. The tone sandhi rule, for example, turns the first of two consecutive falling-rising tones into a mid-rising tone. In addition, under certain circumstances the diphthong /ay/ is monophthongized. Yip (1982:fn.5) shows that the ordering of the P-rules before secret language formation will result in the wrong output. In chapter 5, we will discuss vowel coalescence in Rotuman (futi vs. fÜt 'to pull'..etc.) and it will become apparent that this rule applies to forms which have undergone metathesis. We take the examples from Finnish, Chinese and Rotuman to be evidence for the claim that rules of transposition only apply at the deepest level of the phonological component, that is, before the rules of tier decomposition. Hence, the assumption that metathesis rules apply prior to the tier decomposition rules explains why these rules are restricted to segments, and why subsegmental constituents cannot be metathesized. Under the static conception, on the other hand, the assumption that rules of transposition are restricted to a particular level in the phonological component is insufficient, since subsegmental constituents are available for phonological processes throughout the phonology.

1.1.3.4 Feature asymmetries

A longstanding issue in phonological theory concerns the status and representation of the 'major class features' (MCFs). Selkirk (1984) proposes that the MCFs [syllabic], [sonorant], [consonantal] be eliminated from phonological theory, especially in view of the theory of the phonotactics of the syllable, and that they be replaced by the sonority hierarchy and the assignment of a sonority index to individual segments that reflects their position in that hierarchy. In other words, she claims that there is a single n-ary feature [sonority].

It is a well-known view that there is a sonority peak in every syllable, which is preceded and/or followed by a sequence of segments with progressively increasing/decreasing sonority. In addition, in particular languages the phonotactics of the syllable are even more constrained. Harris (1983) points out that syllable theory must have a way of specifying the minimal sonority difference between two adjacent positions in a syllable.

Of interest to us is the observation that it is the set of MCFs that characterizes what constitutes a natural class for the rules of core syllabification, that is, the sonority hierarchy and the minimal sonority difference follow completely from the MCFs. Thus, a statement like (35a) is typically found in phonotactic descriptions, unlike (35b):

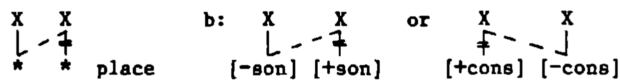
(35) a: The onset of a syllable in L can be occupied by a sequence of a [-son] and a [+son] consonant.

b: The onset of a syllable in L can be occupied by a sequence of a [-voice] and a [+high] consonant.

However, there are exceptions. For example, many languages are reported in which a sequence of two coronals (*tl, *dl), or two labials (*bw, *fw) are disallowed in the syllable onset. These constraints are not arbitrary, but reflect a widespread dissimilation tendency to avoid syllables containing sequences at the same place of articulation, as is observed by Clements (1987b). He notices that it is doubtful whether constraints of this type should be expressed in terms of sonority. He suggests to derive them from independently motivated principles like the Feature Contrast Principle and the Principle of Sequential Markedness.

Another interesting observation is that the individual MCFs do not participate in assimilation and dissimilation rules. Hence, we typically find rules of the type in (36a), whereas those in (36b) are systematically absent:

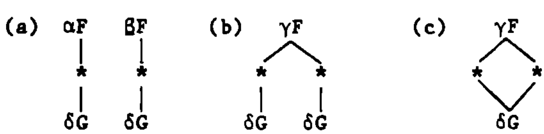
(36) a:



A third asymmetry concerns the Shared-Features Convention (SFC) proposed by Steriade (1982) and restated in Clements (1985). This convention states that when the output of a rule creates a representation in which at least one feature matrix is shared between two adjacent slots, then all remaining identical features undergo merger:

(37) Shared-Features Convention:

Given a representation satisfying (b) resulting from a representation satisfying (a) as the result of a rule, where F, G are single features and the dots designate root tier nodes, (b) is converted into (c):



(Clements 1985:240)

The following external sandhi facts from Classical Sanskrit show, however, that it appears that the major class features are not subject to the SFC, as pointed out by Wetzels (1986).[6] Two phonological changes are of importance here. First, word-final obstruents acquire the feature [voice] from the initial segment of a following word; then the voiced coronal fricatives /z, ẓ/ become [r] by a rule of rhotacism. The examples in (38), taken from Whitney (1889) and Carnoy (1925), show the effects of these rules:

(38) a: śas si → śassi 'you order'
tatas tē → tatastē 'then of you'
cakeus tē → caksustē 'your eyes'

b: manuṣ gacchati → manurgacchati 'the man goes'
sarvāiṣ guṇāiḥ → sarvāirguṇāiḥ 'by all qualities'
dēvapatiṣ yathā → dēvapatir yathā 'like the lord of the gods'

The rhotacism rule takes /z, ẓ/ as its input and not /s, ṣ/ since in that case we would wrongly derive *tatarte..etc., and be forced to complicate the rule of rhotacism. By ordering voicing assimilation before rhotacism we can keep the grammar as simple as possible and derive the facts in (38). However, the rule of voicing assimilation creates a shared matrix for the feature [voice], and if the SFC held for the MCFs one would expects that, in case of medial //manuẓ gacchati//, the identical features [+cons] and [-son] merge. Given the fact that the rule of rhotacism changes the value for [sonorant] into [+son], we make the incorrect prediction for the example at hand. We predict that rhotacism cannot take place because of the Linking Constraint, which states that association lines mentioned in the SD of phonological rules must be interpreted as exhaustive. The rule of rhotacism changes the feature [-son] in a word-final /z, ẓ/ into [+son]. However, in //manuẓgacchati// the feature [-son] is shared by the two obstruents, and this entails that the Linking Constraint would make [-son] immune to rhotacism in this example. If the SFC does not hold for the major class features, this problem does not arise, since in that case the MCFs [+cons] and [-son] will not merge, and rhotacism can apply freely. In the static view a stipulation to this effect must be added to the grammar.

The problem here is how to account for the asymmetries, schematically represented in (39), between major and non-major class features.

(39)

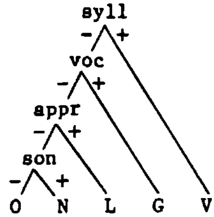
	major class	non-major class
syllabification	+	-
assimilation	-	+
SFC	-	+

Selkirk (1984) solves the first two asymmetries by eliminating the MCFs entirely and replacing them by the sonority hierarchy. How she solves the third is unclear, however, since the rule of rhotacism above refers to the feature [son] in its structural change, while this feature is eliminated from the theory. A possible way of stating rhotacism in Selkirk's theory is to assume that the sonority index changes by means of this process. Thus, Selkirk, in her attempt to eliminate the major class features, takes the sonority hierarchy as a theoretical primitive.

Let us now consider the opposite position, and follow a proposal by Clements (1987b). Clements suggests that the sonority hierarchy should be derived by ranking the MCFs as shown in (40):

(40)

	O<	N<	L<	G<	V
syllabic	-	-	-	-	+
vocoid	-	-	-	+	+
approximant	-	-	+	+	+
sonorant	-	+	+	+	+
rank	0	1	2	3	4

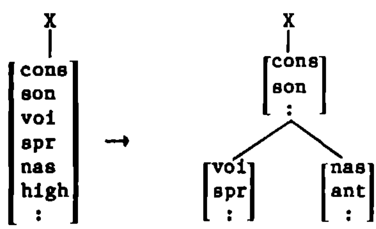


Given this feature ranking, we do not require the n-ary feature [sonority], and the sonority hierarchy can be deduced from the phonetically motivated features. However, by deriving the sonority hierarchy as proposed by Clements (1987b), we cannot explain the asymmetries displayed in (39).

The representation of the major class features is not systematically discussed in Clements (1985) and Sagey (1986b). Clements (1985) tentatively assumes that they are dominated by a manner tier node, whereas Sagey (1986b) assumes that the root node is multiple-branching into the laryngeal and supralaryngeal class nodes and the single features [consonantal] and [continuant]. Neither of them provides evidence supporting their respective views. This makes a comparison with our alternative representation proposed in section 1.1.2. pointless.

In our feature geometry the MCFs constitute the melodic root after the first rule of decomposition (6a), repeated here as (41):

(41) a:



(Root — Laryngeal Supralaryngeal)

Let us recall our assumption that features contained within (sub-)matrices are inaccessible for rules of assimilation and dissimilation. One immediate advantage of this assumption is that we can explain why rules like (36b) are systematically excluded in human languages. Furthermore, we predict that rules which refer to MCFs in their structural description are so-called complete assimilation rules. As far as we know this prediction is correct. Hence, the feature geometry proposed accounts for the first asymmetry in (39).

The second asymmetry noticed above relates to the principles of core syllabification (cf. 39). In our concept, the MCFs are immediately dominated by the skeleton, whereas all non-major class features are dominated by the skeleton only indirectly. We thus assume a hierarchical distinction between these two classes of features. This enables us to invoke Hammond's (1984:139) Metrical Locality Condition to account for the second asymmetry. This constraint determines the kind of information a prosodic rule has access to. Rules referring to elements at one level may refer to the level they immediately dominate, but not to structure beyond that level, that is, tree construction rules (syllabification rules, foot formation..etc.) are strictly local.

(42) Metrical Locality
A rule operating on level n in the metrical hierarchy cannot refer to structure on level m, where m > n+1 or m < n-1.

Metrical Locality explains why, for instance, rules deleting a low vowel in a metrically weak position of the foot or word tree do not occur. Such rules apply at the foot level and would require information from a prosodic level which is not immediately dominated, in this case the melody. Given Metrical Locality, however, rules applying at the foot level can have access to the level of the syllable, but cannot look beyond that prosodic level.

In our case, the rules of core syllabification apply at the level of the skeleton, and this implies that the level immediately below the skeleton is accessible. On the assumption that the rules of syllabification are ordered after the decomposition rule (41) the second asymmetry is expected. The non-major class features are represented at a level where they are not immediately dominated by the skeleton, and therefore cannot be referred to by the rules of core syllabification.

It is not our purpose to present a syllable theory in full detail along the lines suggested, since this would take us too far away from the main topic of this thesis. The preceding discussion only served one cause, viz. to explain the well-known asymmetry between major and non-major class features as a result of their representation in the geometry. A note of caution is necessary, however. We have restricted the discussion to the rules of core syllabification. Such a restriction has to be made, because in many languages one finds statements such as the following: the onset can consist of three consonants of which the first can only be /s/; or a rime may contain four positions (e.g. VVCC or VCCC) - if it does, the last member must be a coronal obstruent. Similarly, some languages seem to require negative syllable constraints that rule out onsets made up of two coronal or labial consonants. These constraints, however, fall outside the domain of core syllabification. Levin (1985) assumes that the core syllabification rules generate maximal core syllables of the following type: CVVC or CVCC. Furthermore, she introduces supplemental rules of syllabification which fall into two types. First, rules of incorporation which incorporate additional C-slots into the syllable, and which obey the minimal sonority constraints of the language in question. Second, rules of adjunction, which adjoin the remaining extrasyllabic slots into the syllable. These rules do allow for sonority violations and are limited for the most part to peripheral positions. The additional constraints with respect to the onset and the rime are of the latter type. The syllabification rules that adjoin /s/ to a CCC-onset and /t, s/ to a VXCC-rime do not obey the sonority hierarchy. In our approach, we have to stipulate that the rules of adjunction are not restricted by the Metrical Locality Condition. The approach to the negative syllable constraints must be slightly different. The rules of incorporation will generate onsets of two consonants having the same place of articulation. These rules obey sonority requirements, and consequently allow for tl or bw onsets. Additional language-specific constraints (cf. Clements 1987b) will filter out these sequences.

The external sandhi facts of Classical Sanskrit which show that the SFC can only merge non-major class features follow without further stipulation from the hierarchy in (7a) and the formulation of the SFC itself. An MCF is represented as a single unit which is the highest node in the feature tree, i.e., there is no root tier which dominates an MCF. This view entails that the structural description of the SFC is never met. There is one general exception, though. If two identical root nodes share all the subordinate nodes, the roots themselves must also merge to produce a true geminate.[6] That this is necessary is shown by some additional facts of Sanskrit. Geminate /rr/s are excluded in the language. They always undergo a degemination rule with subsequent compensatory lengthening of the preceding vowel as illustrated in (43):

(43)	a:	punar ramata	→ punāramata	
		jyōtir ratha	→ jyōtīratha	
	b:	nṛpatis rājata	→ nṛpatīrājata	(sr → zr → rr → r)
		dus rōhaṇa	→ dūrōhaṇa	(id.)

1.1.4 Summary

Our attention has focused primarily on the representation of distinctive features. We have outlined a theory of tier decomposition by which features acquire autosegmental status in the course of the phonological derivation. This concept contravenes the usual one in nonlinear phonology, proposed in e.g. Clements (1985) and Sagey (1986b). In their view, the feature geometry is preexistent, whereas we assume that the geometry is derived. Various arguments have been put forward that bear on this issue. We have shown that the static or tree concept loses much of its attractiveness in the light of processes such as laryngeal assimilation in Classical Sanskrit and rules of transposition in general. These processes all force us to recognize a level in the grammar in which single features and/or subtiers are inaccessible. Furthermore, the Sanskrit facts provide strong evidence for the claim that class nodes are not abstract entities, but are made up of distinctive features. Under this interpretation the class nodes can be the terminal nodes in the geometry. In the tree conception single features are the terminal nodes in the geometry throughout the phonology. This entails that rules affecting class nodes and rules affecting single features are equally marked. However, in the light of the restrictions on laryngeal assimilation and rules of transposition, various additional stipulations have to be added, to account for: (i) the absence of e.g. [spread] assimilation independently of the voice specification as opposed to normal laryngeal assimilation which involves both features, and (ii) the absence of rules of transposition by which single features or subordinate class tier nodes undergo permutation.

Secondly, we have shown that recognizing a stage in the grammar where single features or sets of features are inaccessible for assimilatory processes, enable us to distinguish two types of P-rules, viz. feature-changing or feature-copying redundancy rules versus feature-spreading assimilation rules. We have shown for a well-known example from English (Velar Softening) that feature copying must be assumed to be a primitive rule type. We have suggested to reserve the feature-changing type to account for alternations which are highly morphologized and fossilized, and for which it is doubtful whether a speaker "mentally derives" one form from the other.

Finally, we have discussed the asymmetry between major and non-major class features, and we have argued that these asymmetries can be derived from the geometry proposed in section 1.1.2. This discussion relates only indirectly to the previous issue. It is possible to accommodate the geometries proposed by Clements and Sagey in such a way that the MCFs are contained within their root node. Nevertheless, this discussion once again shows that not all single features are accessible for spreading and/or delinking rules, and therefore it provides evidence for our interpretation of the notion of class node as a matrix containing distinctive features.

1.2 Underspecification Theory[8]

In generative phonology, a crucial distinction is made between underlying and surface representation. This distinction follows from one of the central goals of the generative enterprise, which is to discover linguistically significant generalizations. Information concerning the sound pattern of a language which is expressible by rule is omitted from underlying representation. For example, in Dutch, the distinction between voiced and voiceless obstruents is neutralized syllable-finally (cf. hon[t] vs. hon[d]en 'dog(s)', hui[s] vs. hui[z]en 'house(s)'). If a rule of Final Devoicing is posited, the necessity of listing both allomorphs disappears. The presence of a single neutralization rule permits a radical reduction in the lexicon. It is this line of reasoning which supplies much of the motivation for a rule-based theory of phonology.

Given the fact that lexical entries are conceived as chains of distinctive feature matrices, one could, in the light of this ask whether the redundancy in these matrices should also be omitted from underlying representation, in order to be reintroduced later in the derivation.

The smallest units in phonology are assumed to be binary distinctive features. Research in the past decades has revealed that the number of features necessary to describe the sound patterns of human languages is relatively small. Moreover, it has become apparent that within particular segmental classes not all features are exploited in underlying contrasts. For example, in the class of vowels the features [continuant] and [voice] are never distinctive; within the class of consonants, however, these features normally are. If one adheres to the assumption that predictable information be eliminated from underlying representation, redundant feature values must be left unspecified in lexical representations. The subtheory which takes up the task of formalizing this idea has become known as Underspecification Theory (henceforth UT). Two major approaches can be distinguished. We will explain the differences on the basis of a concrete example.

Let us assume a language L which has the following sound inventory: /p,b,t,d,k,g,m,n,ŋ,r,l,i,e,a,o,u/. In this system the features [spread] and [constricted] are fully predictable, i.e. they are not phonologically distinctive in any set. The features [voice] and [nasal], on the other hand, are used to minimally distinguish some sounds from others: [voice] is distinctive in obstruents and predictable in sonorants; [nasal] is distinctive in stops but not nowhere else.

In the first approach to underspecification, features can be removed from lexical representation, if they can be predicted from other features. Features that are phonologically distinctive in a certain sound class are fully specified for all the members of that class. Under this approach, the sound inventory of L can be specified as in (44) below, where the zeroes indicate the absence of a particular feature in the lexical representation of a phoneme:

(44)

	p	b	m	t	d	n	k	g	ŋ	r	l	i	e	a	o	u
voice	-	+	0	-	+	0	-	+	0	0	0	0	0	0	0	0
nas	-	-	+	-	-	+	-	-	+	0	0	0	0	0	0	0
spread	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Redundancy rules will fill in the missing values. This kind of approach goes back to the Prague School (cf. Trubetzkoy 1939) and in early generative phonology was adopted by Halle (1959). He assumes that these redundancy rules are ordered among the P-rules. However, Lightner (1963) and Stanley (1967) raised various formal problems for this approach. The most important and influential objection is that it allows P-rules to distinguish [0F] from both [+F] and [-F], and therefore permits a zero-value to act as a third value in a binary system. Empirical problems raised by blank-filling rules played a relatively minor role in the discussion.[9] Nevertheless, generative phonologists have taken this objection seriously, because it is believed that human languages do not utilize the expressive power generated by allowing rules that make nondistinct representations distinct.

Stanley's criticism has led to the view that redundancy rules apply prior to the application of all P-rules. This is essentially the position taken by SPE, Kean (1975), and later work in the same vein. Recently, the Prague School approach to underspecification was taken up again by Steriade (1987b).[10] We will return to Steriade's elaboration of this approach in greater detail below.

The second major approach to underspecification is rather different. It claims that lexical entries contain only the minimal amount of information which is necessary to distinguish between representations. For the lexical representation of sounds, this entails that one and only one value of a contrastive feature can be represented. In our hypothetical language L we can take [+voice] and [+nas] as the lexical values (it is not necessarily the positive value of a feature that is lexical, for other features the negative one may be lexical), and fill in the zero-values later by language-specific or universal redundancy rules.

(45)

	p	b	m	t	d	n	k	g	ŋ	r	l	i	e	a	o	u
voice	0	+	0	0	+	0	0	+	0	0	0	0	0	0	0	0
nasal	0	0	+	0	0	+	0	0	+	0	0	0	0	0	0	0
spread	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

This variant of underspecification is presented in Kiparsky (1982, 1985) and has been further developed for tonal phenomena within the framework of lexical phonology by Pulleyblank (1983), and within autosegmental phonology by Archangeli (1984), and Archangeli and Pulleyblank (1986).

Below, we will compare the underspecification theories developed by Archangeli (1984) and Steriade (1987b). Next, in section 1.2.2, several arguments in favor of UT will be reviewed. In section 1.2.3, we will counter some of the objections raised against theories of underspecification, and finally, underspecification theory will be compared with the so-called single-valued feature approach, as that adopted in e.g. Dependency Phonology.

1.2.1 A comparison of Archangeli (1984) and Steriade (1987b)

Archangeli (1984) presents a well-articulated theory of underspecification in which the use of minimally specified feature matrices in underlying representation is exploited. In this theory, the missing values for all features are supplied by redundancy rules. In the lexical representations of sounds only those feature values are specified that distinguish one segment minimally from any other. Thus, the underlying representation of Yawelmani vowels is argued to be the following:

(46) Yawelmani vowels:

	i	a	o	u
high		–	–	
round			+	+

A fully specified representation of this vowel system can be obtained by the application of the set of redundancy rules in (47):

(47)

a:	[ ]	→ [+hi]	d:	[+lo]	→ [+bck,−rnd]
b:	[+rnd,−hi]	→ [−lo]	e:	[ ]	→ [−rnd]
c:	[−αhi]	→ [αlo]	f:	[−lo,αrnd]	→ [αbck]

Archangeli claims that redundancy rules fall into three subtypes: 1) learned rules, 2) complement rules, and 3) default rules. The last two are defined by Universal Grammar and do not have to be learned. The universal default rules are context-free and supply the missing values, which are determined by UG. This type of rule is only superficially different from the markedness rules proposed by SPE and Kean (1975).

Complement rules are rules which are automatically created when a given underlying representation is learned. To be more concrete, let us suppose that the universally marked value for [high] is 'minus'. A default rule will then introduce [+high], which is considered to be the universally unmarked feature value. In contrast, if a language takes [+high] as the lexical value on language-internal grounds, there is no appropriate default rule to assign the missing value. Consequently, a language-specific complement rule is created which supplies [-high].

An important property of redundancy rules is that they do not change feature values; they only insert a particular value in a certain environment. In this respect they differ from the P-rules proper, which are allowed to change feature values. This difference between P-rules and redundancy rules is expressed by the Distinctness Condition (48):

(48) Distinctness Condition:
The input to a redundancy rule is not rendered distinct[11] from the output by application of the redundancy rule.
(Archangeli 1984:46)

All ordering relations in (47) are either predicted by universal principles, or left unspecified, i.e. these rules are unordered. For example, rule (47b) is disjunctively ordered before (47c) by the Elsewhere Condition in (49), while (47a) is unordered with respect to (47e):

(49) Elsewhere Condition:
Rules A and B in some component apply disjunctively, if and only if:
a. The input of A is a proper subset of the input of B
b. The output of A and B are distinct.
In that case, A (the particular rule) is applied first, and if it takes effect then B (the general rule) is not applied.
(Kiparsky 1984:137)

In addition, (47b) and (47c) must precede (47d,f), since otherwise there are no values for the feature [low] that can act as the trigger. Archangeli proposes the Redundancy Rule Ordering Constraint (50) to deal with this type of ordering:

(50) Redundancy Rule Ordering Constraint: (RROC)
A redundancy rule assigning "a" to F, where "a" is "+" or "-", is automatically ordered prior to the first rule referring to [aF] in [its] structural description.
(Archangeli 1984:85)

A second and more important result obtainable from the RROC is that we need not assume that redundancy rules are ordered prior to the P-rules. According to Archangeli, redundancy rules apply as late as possible. A theory without the RROC is open to the criticism raised by Lightner (1963) and Stanley (1967) that a binary feature system is used in a ternary way. If it were allowed to have [+F], [-F] and [0F] in the same environment, then three distinct matrices can be derived from them, thus allowing zero to act as a third value. However, if we adopt the RROC there is no way to render segments unspecified for F distinct from segments specified as [+F], or distinct from segments specified as [-F]. Archangeli illustrates the usefulness of the RROC for the hypothetical grammar in (51):

(51) a:

	A	B	C
[F]	+	-	0
[G]	0	0	0

b: P-rule:

[+F] → [-G]

c: Redundancy rules:

(i) [ ] → [+F]
(ii) [ ] → [+G]

If redundancy rules are ordered among the P-rules two different situations may arise. In a grammar lacking the RROC, application of the rules in (b) and (c) may render the sounds A, B and C distinct (cf. 52a). In a grammar with the RROC this three-way distinction can never arise. The RROC automatically orders redundancy rule (i) before P-rule (51b) as is shown below:

(52) a:

	A	B	C		A	B	C		A	B	C
[F]	+	-	0	(b)	+	-	0	(c)	+	-	+
[G]	0	0	0		-	0	0		-	+	+

b:

	A	B	C		A	B	C		A	B	C		A	B	C
[F]	+	-	0	(ci)	+	-	+	(b)	+	-	+	(cii)	+	-	+
[G]	0	0	0		0	0	0		-	0	-		-	+	-

Finally, Archangeli (1984:50) proposes the Feature Minimization Principle. This principle seems necessary to avoid the improper use of underspecification. "Given a phonology using n features, we can define n+1 phonemes simply by supplying a single value to a single feature for each phoneme, and leaving one featureless" (Archangeli 1984:49). It is possible, however, to decrease the number of features specified and consequently increase the number of specified feature values. At this point, we must decide which option is preferable. Archangeli decides for reasons largely irrelevant here, in favor of the latter option by introducing the Feature Minimization Principle:

(53) Feature Minimization Principle:
A grammar is most highly valued when underlying representations include the minimal number of features necessary to make different the phonemes of the language.

Let us turn now to the alternative theory of Steriade (1987b). She draws a distinction between two types of predictable feature values, and argues that only one type of predictable feature value is systematically absent from underlying representation: those predictable from feature cooccurence restrictions. In our hypothetical language L in (44) voicing is partly predictable. Within the class of sonorants the feature [voice] is predictable, since all sonorants are [+voice]. Within the class of obstruents, however, voicing is distinctive. If it is assumed that only one value of [voice] is lexically specified, then voicing is also predictable for half of this class. Steriade argues that the two types of predictable values must be properly distinguished, and therefore proposes two types of redundancy rules: (i) D-rules that introduce the non-underlying feature value (i.e. D-value) within a segmental class, where both values of a feature [F] are allowed, and (ii) R-rules that introduce the non-underlying feature value (i.e. R-value) within a segmental class, where a cooccurence restriction blocks one value of [F]. In our example, [-voice] is introduced in the class of obstruents by a D-rule, and [+voice] is introduced in the class of sonorants by an R-rule.

Steriade then shows that there is abundant evidence for the claim that R-values are absent underlyingly, while there is hardly any evidence that D-values are missing. A caveat must be added, though, since the type of evidence Steriade takes into account is obtained only from long-distance assimilation and dissimilation rules, and evidence from, for instance, rules of vowel epenthesis or rule simplification, brought forward in Archangeli (1984), is systematically lacking. Steriade assumes that if a rule propagates the feature [F], then any segment intervening between the trigger and target is unspecified for [F]. Below, we will discuss two examples that provide evidence for missing R-values: sibilant assimilation in Ineseño Chumash, and lateral dissimilation in Latin. Next, we will present what seems to be one of the strongest cases for missing D-values, viz. voicing dissimilation in Japanese.

Chumash has five coronal consonants: /t, s, š, n, l/. The differentiating feature for /s/ and /š/ is [anterior]. For the other coronals, the feature [anterior] is redundant, that is, all three are [+ant], and their [-ant] counterparts do not occur in Chumash. Steriade therefore assumes that /t, n, l/ are unspecified for [ant], while /s/ and /š/ are specified as [+ant] and [-ant], respectively. Within a word, the rightmost /s/ and /š/ trigger [anterior] harmony for preceding sibilants. Intervening segments, including the coronals /t, n, l/ are transparent. Some relevant examples are presented in (54):

(54)	k-sunon-us	'I obey him'	vs.	k-šunon-uš	'I am obedient'
	š-api-tšo-it	'I have good luck'		s-api-tso-us	'he has good luck'
	uqsti	'of throwing'		š-uxšti-meš	'throw over to'

We can observe that both /s/ and /š/ act as trigger, indicating that both must be specified for anteriority. If assimilation only operates under strict adjacency between elements of the relevant tier, in this case [anterior], the transparency of the coronals /t, n, l/ can only be accounted for by assuming that the R-value for [anterior] is absent.

Consider now the rule of lateral dissimilation in Latin. The adjectival suffix -alis becomes -aris if the liquid in the stem closest to it is [+lat]. If an /r/ intervenes between a stem-internal /l/ and the suffix /l/, dissimilation does not take place. However, no other intervening [-lat] sound has this blocking effect. The forms in (55) show the relevant alternations:

(55) a: nav-alis 'naval', semin-alis 'seminal'
b: sol-aris 'solar', milit-aris 'military', lati-aris 'of Latium'
c: flor-alis 'floral', sepulchr-alis 'funereal'

The rule of lateral dissimilation can be stated as follows:

(56) Latin Lateral Dissimilation: (LD)
[+lat] → [-lat] / [+lat] — (in the suffix -alis)

Given the observations in (55b), both values of [lateral] must be present within the class of liquids, the only class in which this feature is ever distinctive. If /r/ is specified as [-lat] it becomes clear why it is a potential blocker for dissimilation. Furthermore, if the non-liquids, which are redundantly [-lat], are unspecified for laterality, the transparency of these sounds is expected. In (57) some sample derivations are given:

```
(57) a:  +1 +1           +1 -1
          |  |            |  |
        soL-aLis   LD   soL-aLis     [solaris]

     b:  +1   +1          +1   -1
          |    |           |    |
        miLit-aLis  LD  miLit-aLis  [militaris]

     c: +1-1 +1
         | |  |
        fLoL-aLis  LD   n.a.         [floralis]
```

Let us now consider voicing dissimilation in Japanese, a phenomenon which differs crucially from the preceding, because the D-value for [voice] must be taken to be absent underlyingly, if one wants to maintain the claim that assimilation and dissimilation rules apply under strict adjacency of trigger and target. Consider also Japanese Rendaku, a rule of sequential voicing, in which the initial obstruent of the right-hand constituent of a compound becomes voiced. The examples in (58) from Itô and Mester (1986) are illustrations of this process:

(58)	iro+kami	→ irogami	'colored paper'
	de+kuči	→ deguči	'exit'
	yo+sakura	→ yozakura	'blossoms at night'
	hana+či	→ hanaǰi	'nose bleed'

Rendaku is subject to a condition known as Lyman's Law (LL), which undoes the effect of Rendaku if the second constituent already contains a voiced obstruent as in (59):

(59) a:	hana+kazari	→ *hanagazari	'flower decorations'
	onna+kotoba	→ *onnagotoba	'feminine-speech'
	kami+kaze	→ *kamigaze	'divine wind'
b:	mizu+seme	→ mizuzeme	'water torture'
	onna+kokoro	→ onnagokoro	'feminine-feelings'

Itô and Mester (1986) argue that LL must be stated as a dissimilation rule ordered after Rendaku. A notationally slightly different version of their rule is (60):

(60) **Lyman's Law:**

$$\begin{array}{cccc} & [+voi] & [+voi] & \\ & \nparallel & | & \\ [& C' & C &]_{\mu} \end{array}$$

We can observe from the data in (59) that LL is a long-distance dissimilation rule. We do not have to include variables into the rule if we assume that obstruents are lexically specified for [+voice], that the D-value [-voice] is supplied to obstruents by a D-rule, and that [+voice] is assigned to the sonorants by an R-rule. The absence of the D-value for [voice] in the obstruents is motivated, since voiceless stops do not interfere with LL (cf. onnakotoba). The absence of [+voice] in sonorants is motivated by the observation that they neither activate nor block LL. Two relevant derivations are given in (61):

(61) a: TaiKuTSu+SinoKi (+v linked to K) Rendaku ..SinoKi (+v +v linked to S and K) LL ...SinoKi (+v delinked from S, +v linked to K)

b: onna+KoToPa (+v linked to T) Rendaku ..KoToPa (+v +v linked to K and T) LL ...KoToPa (+v delinked from K, +v linked to T)

At first sight, it would appear that the theories proposed by Archangeli (1984) and Steriade (1987b) are incompatible. However, this impression may only be apparent. The notions of D-value and R-value, and by the same token, D-rule and R-rule, can also be incorporated in a theory of minimal specification advocated by Archangeli (1984). In (46) and (47) above, we have given the underlying representation of the vowel system of Yawelmani and the redundancy rules supplying the missing values. In the theory proposed by Steriade (1987b) the underlying representation would be slightly different, if D-values are present. The alternative representation of the Yawelmani vowels is as in (62):

(62) **Yawelmani vowels**

	i	a	o	u
high	+	-	-	+
round	-	-	+	+

The absent values for [back] and [low] are R-values and consequently they can be assigned by the following set of R-rules:

(63) **Set of R-rules**

a: [+hi] → [-lo]　　　c: [+lo] → [+bck]
b: [-hi, αrnd] → [-αlo]　　　d: [-lo, αrnd] → [αbck]

To arrive at the underlying representation assumed by Archangeli (1984), we have to assume that [+high] and [-round] are D-values supplied by the D-rules in (64):

(64) **Set of D-rules**

a: [ ] → [+high]
b: [ ] → [-round]

We may conclude that the crucial difference between the theory developed by Archangeli (1984), and the one proposed by Steriade (1987b) seems to be that the latter assumes that D-values are specified underlyingly, while the former assumes that they are absent. The choice between the two theories is of course an empirical issue. Below, Steriade's (1987b) theory will be taken as a point of departure and we will investigate whether the full power of Archangeli's theory is ever necessary.

Archangeli (1984:35ff) notes that asymmetries in the distribution of phonological features and in phonological rules provide strong evidence for a theory of minimal specification. Pulleyblank (1983) discusses tonal phenomena in Yoruba where the high and low tones frequently occur in the structural descriptions and changes of rules, whereas the mid tone never does. This can be accounted for if the mid tone is fully unspecified underlyingly, and if the features marking the mid tone are supplied by D-rules. Furthermore, Harris (1980) discusses several vowel epenthesis rules in Spanish. He notes a striking similarity between these rules, which all insert a vowel of the same quality. Again, this can be explained, if the epenthetic vowel is featureless. The redundancy rules which assign the missing values for the underlying vowel also supply the missing values for the epenthetic vowel. Hence, it seems that these rules of epenthesis provide much stronger evidence for missing D-values than the long-distance assimilation and dissimilation rules discussed by Steriade (1987b).

In this thesis, we will assume that D-values are lexically specified, unless language-internal evidence is present that motivates a deviation from this line. Lexical representations therefore are less redundancy-free in our view than that of Kiparsky (1982, 1985), Archangeli (1984), and others.

If underlying representations are not maximally redundancy-free, we have to decide to precisely what extent they are. It is one of the cornerstones of generative phonology that P-rules must express linguistically significant generalizations which must be detectable from the empirical facts by the presence of alternations, allophonic variation.. etc. If we adopt a UT we must ask whether this subtheory is liable to the same constraints. Hence, the relevant question is: are language learners capable of detecting redundancy rules, i.e. D-rules and R-rules from the empirical facts to which they are exposed? We think that to a large extent they are, if asymmetries in the distribution of distinctive features and P-rules exist in the language. For example, if in a particular language the epenthetic vowel is /i/ and UG provides the general format of epenthesis, the language learner can infer from this knowledge that [+high], [-round] and [-back], the features defining /i/, are absent underlyingly. If asymmetries in the distribution of distinctive features and P-rules are absent, the language learner cannot possibly decide which value is the lexical and which the default value, so the choice will be purely arbitrary. In that case, two different, equally simple grammars can be constructed: one in which the features are fully specified, and another in which one value is taken as the lexical value and the other is assigned by redundancy rules. The question must therefore be asked which grammar is the one actually selected by the language learner. We will assume that two grammars which are both in accordance with the empirical facts are subject to Kiparsky's (1982:57) Derivational Simplicity Criterion (65):

(65) Derivational Simplicity Criterion: (DSC)
Among alternative maximally simple grammars select that which has the shortest derivations

Kiparsky introduces the DSC to account for the observation that the class of rules that may become lexical are the obligatory neutralization rules. Kiparsky illustrates the effect of the DSC for the rule of Trisyllabic Shortening in English. He considers the question how Trisyllabic Shortening might have become a lexical rule. "Suppose that at a certain period there arose surface exceptions to it such as nightingale...Faced with data such as nightingale two analyses are available to the learner. The first possibility is to take the word "at face value" and set up /nītVngǣl/, with an underlying long vowel. The second, assuming for the sake of the example that an /x/ deleted with compensatory lengthening can still be motivated for this stage of English, is the more abstract /nixtVngǣl/. These two alternatives commit the learner to different assumptions about the phonological rules as well. Underlying /nītVngǣl/ entails that Trisyllabic Shortening is lexical. Underlying /nixtVngǣl/ entails that the rule deleting /x/ is postlexical. But the DSC fixes the underlying form /nītVngǣl/, in turn forcing Trisyllabic Shortening into the lexical phonology. Such restructuring erodes the support for the /x/-deletion rule and eventually brings about its demise" (Kiparsky 1982:58).

Given our assumption that redundancy rules are ordered among the phonological rules, we expect that both types are constrained by the same principles. For the theory of underspecification this entails that the DSC selects that grammar which has the smallest number of redundancy rules, unless language-internal evidence existsthat motivates a deviation. Thus, our theory is reminiscent of the approach to underspecification which goes back to Trubetzkoy (1939) and which has been adopted by Halle (1959) and Steriade (1987b). However, our proposal differs from these approaches in that it allows leaving the D-value of a particular feature unspecified within a segmental class in which this feature is contrastive (= D-class), if and only if language-internal evidence is available that motivates this decision. Hence, our UT has at least the effect of the Steriade's (1987b) approach, and the full power of minimal specification is used only in the presence of further language-internal empirical evidence.

Finally, we will consider the Feature Minimization Principle (53) introduced by Archangeli (1984), and argue that this principle cannot be maintained in its present form. In chapter 2, we will develop a formal theory of coalescence, and argue that coalescence must be characterized as the merger of the supralaryngeal features of two vocalic segments, if and only if these sounds are nondistinct. Schematically, we can represent coalescence as in (66):

$$(66)\quad \begin{array}{cc} V & V \\ | & | \\ [\alpha F] & [\beta G] \end{array} \rightarrow \begin{array}{c} V \quad V \\ \searrow\swarrow \\ [\alpha F, \beta G] \end{array} \quad \text{supralaryngeal tier}$$

In a theory of minimal specification the wrong predictions are made for a language in which vowel coalescence is not structure-preserving, that is, in which the output of coalescence consists of sounds which are not present underlyingly. One clear example of this type is Classical Sanskrit. We will give a brief survey of the Sanskrit facts here. The language has three short vowels i, a, u and five long vowels ī, ē, ā, ō, ū. The long mid vowels ē and ō are secondary; they are the result of vowel coalescence. In (67) some forms are given, illustrating the properties of vowel coalescence:

(67)	a+a → ā	sa cā 'prajaḥ	(←sa ca aprajaḥ)	'and he, offspring-less'
	i+i → ī	atī 'va	(←ati iva)	'beyond like'
	u+u → ū	sūktam	(←su+uktam)	'well-spoken'
	a+i → ē	rājēndra	(←rāja+indra)	'lord of kings'
	a+u → ō	hitōpadēśah	(←hita+udēśaḥ)	'friendly advice'

In a theory of minimal specification, the vowel system can be specified as in (68), where the representations are subject to the requirements that they must be maximally redundancy-free and that sufficient features remain to distinguish all vowels:

		i	a	u			i	a	u			i	a	u
(68)	a:				b:					c:				
	hi		−			hi		−			bck	−		
	rnd			+		bck	−				rnd			+

Given the general format of vowel coalescence in (66) and the output of the coalescence rule of Sanskrit, the wrong predictions are made in all three cases if coalescence takes place at a level where no redundancy rules have applied. The predicted forms are given in (69):

(69)	a: a+i → *ā	b: a+i → ē	c: a+i → *ī
	a+u → ō	a+u → *ā	a+u → *ū

Whatever system in (68) is taken as underlying, the rule of vowel coalescence must refer to a feature which is not specified. By virtue of the RROC, the redundancy rule supplying this absent value will be ordered before VC. In order to derive the correct Sanskrit forms, the redundancy rules specifying /i/ as [−back] in (68a), /u/ as [+round] in (68b) and /a/ as [−high] in (68c), must be ordered before VC. However, if the values for these features are supplied prior to coalescence, we cannot maintain the hypothesis that vowel coalescence is a nonfeature-changing process, which merges nondistinct feature values, as will be shown below. If, on the other hand, we assume that [−high], [−back] and [+round] are the lexically specified feature values in Sanskrit, the VC facts in (67) can be considered the result of the universal VC template in (66).

We will now illustrate the problems caused by the Feature Minimization Principle for the description of vowel coalescence, and, for the sake of brevity, we will restrict our discussion to the underlying representation in (68a), although nothing is crucial about this choice. As noted above, in order to derive the correct forms in (67), /i/ must be specified as [-back] before the rule of VC takes place, or else we would predict that both a+i and a+a sequences merge into [ā] (cf. 69a). The complete set of redundancy rules necessary to describe the Sanskrit vowel system is given in (70):

(70)	a: [ ] → [+hi]	d: [+hi] → [-lo]
	b: [-hi] → [+lo]	e: [ ] → [-bck]
	c: [-hi] → [+bck]	f: [-lo, αbck] → [αrnd]

For coalescence to properly apply, the redundancy rule (70e) must apply first. However, (70c) is disjunctively ordered before (70e) by the Elsewhere Condition, and as a result /i/ will be specified as [-back] and /a/ as [-high, +back] at the point in the derivation where VC applies. In order to account for a+i coalescence, we must explicitly stipulate that [-back] is dominant, and therefore VC becomes a feature-changing rule. Furthermore, we observe that [-high] spreads from left to right, whereas [-back] spreads from right to left, and this indicates that we cannot characterize vowel coalescence as a single assimilatory process, since it involves the spreading of more than one node at the same time and in different directions. In the geometry framework outlined in the previous section, the spreading of more than one node is highly marked and this would imply that coalescence phenomena belong to the set of highly marked processes. The frequency of occurrence of this phenomenon in languages suggests that this conclusion is incorrect.

Vowel coalescence is the only process that requires the application of these redundancy rules by assuming specifications like those in (68). The question therefore arises whether we are on the right track. First of all, we need two redundancy rules and a coalescence rule to describe the facts. Secondly, we are forced to assume that coalescence is feature-changing in nature; and thirdly, for the feature [back] we must explicitly stipulate that [-back] is the dominant, spreading value. Thus we are compelled to assume a relatively complex rule of coalescence and a derivation consisting of three consecutive steps.

These problems can be solved quite easily, if we assume that the representation of the Sanskrit vowel system requires at least specifications for the primary vocalic features [high], [back] and [round]. This slight modification results in the representation (71a). As a consequence, we can maintain the general format of coalescence as is shown in (71b):

(71) a:	i	a	u	b:	a + i → ē			a + u → ō		
hi	0	-	0		-	0	-	-	0	-
bck	-	0	0		0	-	-	0	0	0
rnd	0	0	+		0	0	0	0	+	+

The preceding discussion indicates that the Feature Minimization Principle (53) cannot be maintained in its present form. Archangeli proposes this principle to avoid truly redundant features being used to distinguish the phonemes of a language. We therefore propose to change the phrase "include the minimal number of features necessary" into "does not include R-values". Hence, the revised Feature Minimization Principle will select that grammar which does not include, in underlying representation, R-values to distinguish the phonemes of the language.

In this section, we have argued that the theory of minimal specification advanced by Archangeli (1984) is too strong. The discussion of long-distance assimilation and dissimilation processes shows that there is sufficient evidence for missing R-values in underlying representation, while evidence for missing D-values is scarcely available. We therefore proposed a theory in which D-values are specified underlyingly, unless language-internal empirical evidence is available that motivates the additional step of leaving D-values unspecified.

In the next subsections, we will present a number of arguments in favor of underspecification theory, and we will scrutinize some arguments against it.

1.2.2 Arguments pro UT

In languages one can observe all kinds of asymmetries in the distribution of distinctive features and in phonological processes. Pulleyblank (1983) and Akinlabi (1984) discuss tonal and nontonal phenomena in Yoruba, where three tones appear at the surface: High, Mid and Low. However, only H and L occur in structural descriptions and changes of the tone rules. Yoruba has several rules of vowel truncation. If one of the input vowels is H or L, these tones surface. Crucial in this respect is the property of the M-tone: this tone never surfaces if one of the input vowels carries a H-tone or a L-tone. The following data are taken from Akinlabi (1984):

(72) a:	wá-ɛ̀kɔ́	→	wɛ́.kɔ́	'search for knowledge'	(HLH)
	fɛ́-ìwo	→	fɛ́.wo	'want a horn'	(HLM)
	wá-ɔ̀nà	→	wɔ́.nà	'search for a way'	(HLL)
b:	sè-ɛ̀fɔ́	→	sɛ̀fɔ́	'cook vegetables'	(LLH)
	rà-ìbɔn	→	ràbɔn	'buy a gun'	(LLM)
	tà-ɛ̀wà	→	tɛ̀wà	'sell beans'	(LLL)
c:	jɔ-àjɛ́	→	jàjɛ́	'resemble a witch'	(MLH)
	še-ɛ̀rɔ	→	šɛ̀rɔ	'make a machine'	(MLM)
	še-ɔ̀fɔ̀	→	šɔ̀fɔ̀	'do mourning'	(MLL)

d: wá-owó	→	wówó	'search the money'	(HMH)
wá-ɔkɔ̀	→	wɔ́kɔ̀	'search for motorbike'	(HML)
gbà-ewé	→	gbèwé	'taken leaves'	(LMH)
rà-ɔwɔ̀	→	rɔ̀wɔ̀	'buy brooms'	(LML)

("." indicates lowering of the following tone)

The forms in (72) show that M-tones do not survive vowel truncation, unless both vowels bear M-tones. In addition, after H-tones, L-tones cannot stay either, but, unlike M-tones, they induce the lowering of a following tone before their disappearances. Both Pulleyblank (1983) and Akinlabi (1984) argue that these observations with respect to the asymmetrical behavior of M-tones can be best explained if the M-tone is unspecified. In that case, we have a principled account for the systematic absence in Yoruba of a rule such as (73a) as opposed to (73b):

```
(73) a:  H  M  T      *H  M  T     b:  H  L  T      H  L  T   (where T =
         |  |  |       |   `-.         |  |  |      |   `-.
         V  V  V   →   V   Ø  V        V  V  V  →   V   Ø  V    H or L)
```

Arguments based on rule simplification are not difficult to find. Archangeli (1984) argues that the rule of Rounding Harmony in Yawelmani can be *simplified considerably if redundant values for* [low] *and* [back] are supplied later in the derivation. The rule of rounding harmony turns /i/ preceded by /u/ into [u], and /a/ preceded by /o/ into [o]. If fully specified feature matrices were assumed, rounding must include backing in the case of i → u, and raising in the case of a → o. On the other hand, if /a/ is unspecified for [low], and /u/ for [back], rounding harmony can be stated as in (74):

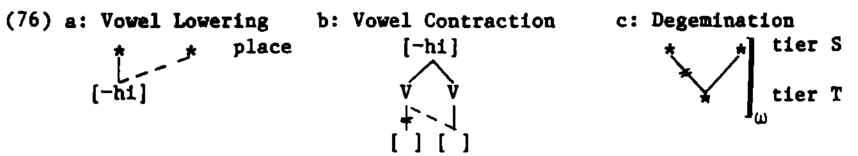
```
(74) Rounding Harmony: (Yawelmani)
       [αhigh]  [αhigh]
         |_ _ _ _/
      [+round]
```

In some cases, UT even permits to eliminate rules altogether or to collapse different rules into single statements. De Haas (1987a) discusses vowel coalescence in Kasem, a West African language spoken on both sides of the northern border between Ghana and Burkina Faso, which has attracted a considerable amount of attention in the literature (cf. SPE, Phelps 1975, 1979, Halle 1978, among others). Of particular relevance for the present discussion are the forms in (75):

(75) class	singular		plural		
A	tu	(←tu-u)	twa	(←tu-a)	'corpse'
	buko	(←buko-u)	bukwa	(←buko-a)	'daughter'
B	ni	(←ni-i)	nia	(←ni-a)	'mouth'
	zwe	(←zwa-i)	zwa	(←zwa-a)	'ear'

C	pia	(←pi-a)	pi	(←pi-i)	'yam'
	pia	(←pe-a)	pe	(←pe-i)	'sheep'
	kua	(←ku-a)	kwi	(←ku-i)	'bone'
	yua	(←yo-a)	ywe	(←yo-i)	'hair'
D	fogo	(←foga-u)	fwadu	(←foag-du)	'die, dice'

These data show that Kasem nominals display a number of alternations. First of all, one observes that high vowels are lowered after nonhigh vowels. In addition, round vowels in prevocalic position undergo a glide formation rule in plural. Thirdly, the sequences a+i and a+u show up as [e], [o] respectively. Finally, identical or nearly identical vowels undergo a rule of vowel truncation. To account for these changes, De Haas (1987a) proposes the following set of rules (besides a rule of Resyllabification, which will not be discussed here):



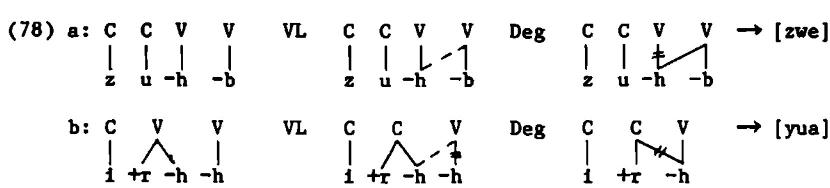
This (1987a) account of the Kasem facts contained an analysis based on completely specified matrices. It was this assumption that necessitated two different rules, Vowel Contraction and Vowel Lowering, to account for what intuitively constitutes one and the same process. The impossibility to collapse these rules was a consequence of the fact that Vowel Lowering must spread [high] from left to right, whereas Vowel Contraction spreads the remaining features from right to left. In addition, a form like /zwa-i/, which undergoes lowering to //zwa-e//, and which subsequently contracts to become //zwee// feeds into Degemination.

If we assume a UT in which the five underlying vowels are characterized as in (77) below, we can entirely eliminate the rule of Vowel Contraction.

(77)	i	e	a	o	u
hi		-	-	-	
bck	-	-			
rnd				+	+

[ ] → [+high]
[ ] → [+back]
[ ] → [-round]
[ ] → [+low] / [—, +back, -round]
[ ] → [-low]

The rules of Vowel Lowering, Resyllabification and Degemination are sufficient to exhaustively describe the allomorphy in the Kasem nominals. Some derivations are given in (78):



```
c: C V C  V  V    VL   C V C  V  V    Deg   C V C  V  V   → [fogo]
   | | |  |  |         | | |  L'-1          | | |  +/-1
   f o g -h +r         f o g -h +r          f o g -h +r
```

Our case study of Ancient Greek, to be presented in the chapters 3 and 4, will contain further examples of rule simplification.

Other arguments in favor of underspecification are to a considerable degree theory-internal. In the feature geometry framework presented in the preceding section, the laryngeal feature [voice] and the degree-of-closure feature [continuant] are represented at different levels of the hierarchy. Hence, we do not expect to find assimilation rules that spread both features as a single unit. One apparent counterexample is discussed in Clements (1985). Kikuyu phonology has a rule that specifies obstruents as [-cont, +voi] after nasals:

(79)	imperative	1.sg.imperfect	
	βur-a	m-bur-eetɛ	'lop off'
	tɛm-a	m-dɛm-ɛɛtɛ	'cut'
	reh-a	n-deh-eetɛ	'pay'
	cin-a	ɲ-jin-eetɛ	'burn'
	kom-a	ŋ-gom-ɛɛtɛ	'sleep'
	γor-a	ŋ-gor-eetɛ	'buy'

Given the feature geometry argued for here, it is impossible to express the spreading of [-cont,+voi] as a single process. According to Clements (1985), however, there is good reason to assume that [voice] is redundant for both obstruents and sonorants. Therefore, the facts in (79) can be accounted for by a rule that spreads only [-cont], and a later R-rule which supplies the missing values for [voice]. Without a certain degree of underspecification, we cannot maintain the strong claim that assimilation rules involve the spreading of single nodes in the feature geometry.

A similar point can be made for Toba Batak, discussed by Hayes (1986b). Hayes argues for a rule of Denasalization, which appears to spread the features [voice] and [nasal] as a single unit. Hayes takes this as evidence for the existence of a Peripheral node, which dominates both features (cf. (9) above for some examples). However, assuming that the voiced obstruents are lexically specified for voice, that the voiceless obstruents acquire the feature [-voice] by a D-rule, and the sonorants [+voice] by an R-rule, we can account for the Toba Batak forms without a Peripheral node. The change /mk/ into [pk] can be described as the delinking of the Nasal tier and the subsequent assignment of [-voice] by a later redundancy rule. An alternative is to posit a rule of Regressive Voice Assimilation that accounts for the absence of consonant clusters disagreeing in voice. Both options conform to the facts, and a priori it is impossible to decide in favor of one of them. It is clear, however, that the Toba Batak facts do not present a problem for the claim that the features [voice] and [nasal] are arrayed on different tiers.

One of the achievements of autosegmental theory is that it allows giving formal content to the notion of locality in phonology (cf. Poser 1982, Archangeli and Pulleyblank 1986). It has been claimed that P-rules cannot apply across an indefinite number of intervening variables, but can only affect nodes that are strictly adjacent, where 'adjacent' implies the absence of nodes on a single tier between trigger and target. This is represented schematically in (80), where (80a) is the structural description of a spreading rule, and (80b) the underlying representation of a string to which the rule is applicable. The claim is that the rule in (a) will apply to the string in (b) if and only if the segment c that intervenes between a and b is unspecified for the assimilatory feature [F]:

(80) a: [F]
    a b

b: [F] ([αF])
    a c b

In (81) and (82) below, two processes are exemplified, backing and rounding harmony in Turkish (cf. Clements and Sezer 1982) and strident palatalization in Kinyarwanda (cf. Kimenyi 1979), which seem to refute the claim that phonological rules can only accomplish local changes:

(81)	nom.sg.	gen.sg.	nom.pl.	gen.pl.	
	ip	ip-in	ip-ḷer	ip-ḷer-in	'rope'
	kɨz	kɨz-ɨn	kɨz-lar	kɨz-lar-ɨn	'girl'
	yüz	yüz-ün	yüz-ḷer	yüz-ḷer-in	'face'
	pul	pul-un	pul-lar	pul-lar-ɨn	'stamp'
	eḷ	eḷ-in	eḷ-ḷer	eḷ-ḷer-in	'hand'
	sap	sap-ɨn	sap-lar	sap-lar-ɨn	'stalk'
	ḳöy	ḳöy-ün	ḳöy-ḷer	ḳöy-ḷer-in	'village'
	son	son-un	son-lar	son-lar-ɨn	'end'

("." indicates palatal /ḷ, ḳ/)

(82)			
	gu-šaš-iiš-a	'to cause to make the bed'	(cf. gu-sas-a)
	ku-užuž-iiš-a	'to cause to fill'	(cf. ku-uzuz-a)
	gu-šaaš-iiš-a	'to cause to get old'	(cf. gu-saas-a)
	a-šamaaž-iže	'he just excited'	(cf. gu-samaz-a)

Archangeli and Pulleyblank (1986) and Steriade (1987a, b) argue that the locality claim can be maintained if we assume underspecification combined with the hierarchical model of feature representation. Details aside, the rules of vowel harmony and strident palatalization can, under these assumptions, be stated in strictly local terms:

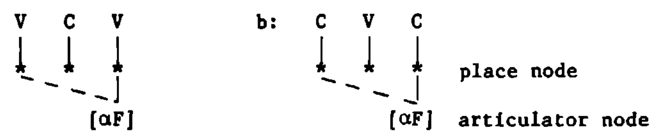
(83)a: Backing Harmony
   * * dorsal
[αbck]

b: Rounding Harmony
   * [+hi] place
[αrnd]

c: Strident Palatalization
[+str] [+str] coronal
* [-ant]

If it is assumed that the transparent consonants in Turkish are unspecified for the dorsal and labial features, we predict that these consonants cannot act as blockers for either harmony rule. On the other hand, the consonants /ḳ, g̣, ḷ/ must be specified for backness in order to distinguish them from /k, g, l/, and it is predicted that the former consonants will block the rule of Backing Harmony. The discussion in Clements and Sezer (1982) shows that this prediction is correct. In addition, if we assume that the noncoronal consonants and vowels are unspecified for the coronal features, we expect that the two occurrences of the class node 'coronal' in (83) are adjacent, although the sibilants themselves are not. Thus, UT and the geometry hypothesis allow us to formalize superficially nonlocal processes in strictly terms.

A final, strong argument in favor of underspecification concerns so-called vowel/consonant asymmetries. Clements (1985) observes that rules of place assimilation exist which take vowels as their input and apply regardless of the number of intervening consonants. On the other hand, we rarely find consonant-to-consonant assimilation rules which take effect regardless of the number of intervening vowels (exceptions are strident palatalization in Kinyarwanda and cerebralization in Sanskrit). Hence, rules of the form in (84a) are very common, whereas rules of the type (84b) are rare:

(84) a:


In the recent literature (cf. Clements 1985, Steriade 1987a, b, Archangeli and Pulleyblank 1986) different proposals are made to account for this asymmetry. These proposals have in common that features are hierarchically organized and that some version of underspecification is crucial. In a theory of full specification, it is impossible to explain the vowel/consonant asymmetry: we simply do not expect to find asymmetries of this sort. However, if we assume that the "plain" consonants are unspecified for the vocalic place features [high], [back], [round]..etc., we expect that vowel-to-vowel rules of place assimilation can ignore intervening consonants, since these segments are transparant with respect to the vocalic place features. In addition, the feature [anterior] is only distinctive in the class of coronal consonants. If we therefore assume that [anterior] is unspecified elsewhere, we can explain why strident palatalization in Kinyarwanda and cerebralization in Sanskrit can ignore intervening noncoronal consonants and vowels. In order to account for the nonoccurrence of "V_0" in consonant-to consonant assimilation rules, Clements (1985) assumes that the consonantal features [anterior], [coronal] and [distributed] are assigned to vowels by default. Given the RROC, these redundancy rules will be ordered immediately before the P-rules which refer to the consonantal features in their structural descriptions, and therefore we predict that vowels will act as blockers for the spreading of the consonantal place features.

This brief discussion is far from complete and many problems remain to be solved. One thing must be clear, though: the theory of underspecification is, at present, the only theory in which it is expected that asymmetries of the type discussed exist in human languages at all.

1.2.3 Arguments against UT

A potential problem for all versions of underspecification is the existence of 'empty' skeleton slots. Clements and Keyser (1983) and many others have argued for the postulation of C or V-slots which are not associated to the melody. According to Clements and Keyser (1983:67) such slots induce automatic spreading of accessible consonants or vowels on the melodic tier. In a theory of underspecification, we are apparently facing a problem, since default vowels/consonants are also conceived of as skeleton slots unspecified for all distinctive features. The important question we could ask is how the redundancy rules supplying D-values and R-values interact with language-specific (spreading) rules. In chapter 3, we will argue that /e/ is the default vowel in Ancient Greek, and that at least two affixation rules, viz. Augmentation and Perfect Reduplication insert an empty V-slot. It will turn out that the two types of empty skeleton slots do not need to be distinguished, because the empty reduplication-V will acquire its phonetic substance from a following vowel by a rule of Leftward Spreading. If, on the other hand, the reduplication V-slot is followed by a consonant, Leftward Spreading cannot take place, and consequently the redundancy rules will fill in the missing feature values (e.g. /V+ethel+on/ → [ḗthelon] 'I wished' vs. /V+lū+on/ → [élūon] 'I lost'. Hence, the observation that the same empty V-slot sometimes surfaces as the default vowel, while, under different circumstances, its phonetic properties result from spreading shows that the two types of empty skeleton slots need not be formally distinguished, if language-specific rules and redundancy rules interact in the way exemplified for Ancient Greek.

A central function of a binary feature system is that it enables us to classify sounds into natural classes, and to make it possible to identify an unnatural class. In a theory of minimal specification it is very hard to give theoretical content to the notion 'natural class'. Suppose a language with a simple five vowel system /i, e, a, o, u/ in which [+high], [+back] and [+round] are lexically specified. If a rule P_1 refers to [+high] in its structural description, there is no problem; the rule will take /i, u/ as its input. However, if another rule P_2 mentions [-high], it is impossible to tell what segmental class is referred to, unless we supply [-high] (as required by the RROC). The vowels /i, u/ thus constitute a natural class underlyingly, whereas the vowels /e, a, o/ do not. A priori, we cannot conclude whether this is the right or wrong prediction. This matter can only be decided on empirical grounds. If P_2 is crucially ordered before P_1 this would surely be a strong indication that UT is of little value in this particular language, unless it is possible to derive the natural-classhood of the [-high] vowels from other aspects of the representation.

In a linear theory, distinctive features were the only tools available to express the notion of natural class. Recent developments in nonlinear theory entail a radical change in this respect. The hierarchical representation of features and the hierarchical formalization of P-rules make it possible to encode into the formalism itself information as to what constitutes a natural class. We will return to this issue in greater detail in section 1.3, where the Linking Constraint will be discussed, and we will argue that certain problems concerning natural classes of sounds can be solved elegantly.

Static syllable constraints seem to pose a serious problem for the theory of minimal specification. Nick Clements has brought to our attention numerous instances in which both values of a feature must be present underlyingly. Let us cite just two. In English, the final C in a tautosyllabic VCCC-cluster cannot be [-coronal]. In addition, the sequence /a l/ cannot be followed by a tautosyllabic [+coronal] consonant. According to Clements, this indicates that both values of [coronal] must be present underlyingly. Christdas (1986, 1987) discusses syllable constraints in the Dravidian language Tamil. She notices that the glides /y, w/ cannot occur before the vowels /i, e/ and /o, u/, respectively, whereas the low vowel /a/ is free to occur after both /y/ and /w/. Hence, it appears that Tamil has a syllable constraint which rules out consonant-vowel sequences of the type [αback] [αback], indicating that both values for [back] must be present underlyingly. The examples above seem to indicate that the D-values for [coronal] (English) and [back] (Tamil) must be present underlyingly. Since we assume a theory of underspecification in which D-values are present underlyingly, the static constraints of English and Tamil do not present a problem. They would be problematic though, if there was language-internal evidence for leaving D-values unspecified underlyingly, but, as far as we can see, no such evidence is available in English or Tamil.

In summary, in this section we have developed a theory of underspecification with at least the power of Steriade's (1987b) approach, whereas the additional power of the minimal specification approach is used if language-internal evidence is available that motivates a further simplification of lexical representations. We have shown that all virtues of a minimal specification theory still hold for our modified UT and that by and large the disadvantages of minimal specification can be avoided.

In our discussion, we also took for granted the idea that distinctive features are binary. There is, however, a growing tendency both within and outside autosegmental phonology to say that phonological features are single-valued. Below, we will present some arguments against such an approach.

1.2.4 Binary versus single-valued feature representation

Until quite recently mainstream generative phonologists have generally assumed binary values for phological features. All features are of this type, that is, they can have the values "+" or "-". In UT, one of these values or both values may be unspecified in underlying representation: the other values are added in the course of the derivation by D-rules and R-rules. In the framework of Dependency Phonology (cf. Anderson and Ewen 1987, among others) segmental structure is viewed entirely in terms of single-valued features or components. In the Government-and-Charm framework (cf. Kaye et al. 1985) a system of unitary elements, each consisting of a bundle of binary features is proposed. Finally, Schane (1984a,b) proposes a theory based on three unitary particles.

These single-valued feature systems comprise the claim that no segment is characterized by the explicit specification that it lacks a certain property. If a segment lacks a property, this is simply absent from its representation.

The differences between traditional SPE-like feature representations, underspecification and single-valued representations are as shown below:

```
(85) a: SPE          b: UT                                c: Single-valued
      [+F] [-F]        (i) [+F]     (ii) [ ] → [-F]           F
       |    |               |                                 |
       X    X               X   X                             X  X
```

Ewen and Van der Hulst (1985) argue that single-valued feature hypotheses are to be preferred over UT as proposed by Archangeli (1984), because their system lacks D-rules.

Steriade (1987b) attacks unitary-feature approaches precisely on the absence of D-values. She shows that long-distance processes of assimilation or dissimilation may apply to representations in which neither D-values nor R-values are present. Such is the case of voicing dissimilation in Japanese and voicing assimilation in Berber. Long-distance assimilation or dissimilation rules may also operate on representations in which D-values are present but R-values are not. Such is the case in lateral dissimilation in Latin and voicing assimilation in Russian. This distinction is of particular interest. In section 1.2.1 we have discussed voicing dissimilation in Japanese and lateral dissimilation in Latin, and it turned out that the differences between these dissimilation rules can be accounted for straightforwardly within UT. However, this distinction cannot possibly be made in a single-valued feature approach, simply because no appeal can be made to D-values.

The necessity of D-values also follows from vowel epenthesis in the Gaelic dialect spoken on the Island of Barra in the Outer Hebrides, as insightfully discussed in Clements (1986b). The Barra consonants fall into two classes, the plain consonants /p, t, k, b, d, g, f, s, x, v, γ, n, r, N, R, L/ and the palatals /t', k', d', g', s, ç, j, r', l', N', L'/ (where the capitals indicate nonlenited sonorants). Clements assumes that labial consonants are unspecified for the feature [back], since this feature is nondistinctive within this segmental class. All other consonants are inherently specified as either [+back] (plain) or [-back] (palatals). Thus, within the class where [back] is distinctive, both values for this feature are present underlyingly. In Barra Gaelic, a rule of epenthesis inserts a vowel between two heterorganic consonants if the first is a sonorant. In addition, the preceding vowel must be short, and the epenthetic vowel picks up the feature values from this vowel in the unmarked case. Some relevant examples are given in (86):

(86) a: ɔrɔm	'on me'	b: mɸr'ev	'the dead'	
marav	'dead'	sʌr'iə	'wooing'	
ämäsir'	'time'	bul'ik	'bellows' (gen.sg.)	
kɛN'ɛp	'hemp'			
c: sära tär'	'towel'	d: inɸxiN'	'brain'	
särav	'bitter'	sänavar	'grandmother' (gen.sg.)	

(ɸ and ʌ are high or mid unrounded back vowels)

The forms in (86a) where the epenthetic vowel is identical to the preceding vowel can be derived straightforwardly. In (86b) the epenthetic vowel occurs in the context following a palatal sonorant. We observe that the inserted vowel differs from the preceding vowel in being [-back]. If we adopt Clements' (1986b) assumption that palatals are inherently [-back], we can formalize epenthesis in such a way that the epenthetic vowel acquires [-back] from the preceding segment specified for [back]. Similarly, the nonpalatals /r, n/ are prespecified as [+back], and we predict that the epenthetic vowel will be [+back] if it is inserted after these consonants. The forms in (86c,d) show that this prediction is borne out.

This discussion demonstrates that both values of [back] must be present in the set of vowels and nonlabial consonants. Otherwise, we would be unable to explain why the epenthetic vowel is in some cases non-identical with the preceding vowel. In a single-valued feature approach additional stipulations would have to be added to account for this phenomenon.

Recently, the force of this Barra Gaelic example seems to have brought single-valued feature adherers to a similar conclusion. In a revision of their (1985) proposals, Ewen and Van der Hulst (1987) argue that a single-valued feature system can provide a satisfactory analysis of the phenomena above, where D-values seem to be necessary. However, their proposal implies that binary oppositions are not represented at the level of distinctive features, but, instead, at the level of the class feature nodes which are potential anchors for single-valued features; therefore, their model strikes one as basically a binary class-feature model. In order to see this, consider the fact that they suggest that palatalized consonants in Barra Gaelic have a secondary-place node dominating the frontness feature [i], the nonpalatalized non-labials have an "empty" secondary-place node, while the labials have no secondary-place node. They account for the data in (86) by proposing the Opacity Condition (87):

(87) Opacity Condition (Ewen and Van der Hulst 1987:56)

A segment S is opaque with respect to [a feature] F iff:

a. S has the class node to which F associates and

b. F is prevented from associating to S by virtue of

i. a filter or

ii. the SD of the spreading rule or

iii. the fact that F is distinctively absent while S is not specified as being the target of an association

The consonants preceding the epenthetic vowel cannot act as a target for spreading, because the rule only takes vowels as its target. The consequences of Ewen and Van der Hulst's analysis are illustrated in (88), where m indicates a labial consonant:

```
(88) a:  i  i      b:  i          c: i          [i] tier
         |                                      
         *  *  *       *  *  *       *     *    S-place tier
         |  |  |       |  |  |       |     |
         *  *  *       *  *  *       *  *  *    place tier
         |  |  |       |  |  |       |  |  |
         V  C  V       V  C  V       V  m  V

     d:     i      e:             f:            [i] tier

         *  *  *       *  *  *       *     *    S-place tier
         |  |  |       |  |  |       |     |
         *  *  *       *  *  *       *  *  *    place
         |  |  |       |  |  |       |  |  |
         V  C  V       V  C  V       V  m  V
```

The crucial case appears in (88b). We expect [i]-spreading to the following consonant. This cannot happen, because of the Opacity-Condition clause (bii). Furthermore, spreading to the right vowel is blocked, since this would entail a violation of the locality condition on phonological rules.

One final argument for binary-feature representations is related to the cross-linguistic properties of vowel coalescence. We will pursue this issue in great detail in the following chapters. Schane (1984a) touches upon the phenomenon of vowel coalescence within his framework of particle phonology. He characterizes vowel coalescence as follows: "the common change whereby [ai] monophthongizes to [e] and [au] to [o] I call...fusion, because the separately occurring particles... fuse or combine into a single complex particle... The very notion of fusion implies that a resulting complex particle contains all and only the particles of the input" (Schane 1984a:40). Below, we will argue that the claim that coalescence is simply the merger of particles, or, by the same token, single-valued features, cannot be maintained.

For the comparison of binary- and single-valued feature systems one further aspect is of interest. Let us confine ourselves to languages which, like Ancient Greek, have a four-grade vowel system, and in which the feature value for [round] implies the value for [back]. In such languages two options seem available for coalescence. In the language exemplified in (89a) the feature value [+back] is dominant, while the feature [-back] is dominant in (89b). The crucial vowel sequences are bold-faced:

(89)

a: Language A	b: Language B
e+e → ē	e+e → ē
e+o → ō	e+o → ō
a+e → ā	a+e → ɛ̄
a+o → ɔ̄	a+o → ɔ̄
o+o → ō	o+o → ō

Binary-feature systems make available both [+back] and [-back] underlyingly or provide them in the course of the derivation. For language A we can assume that [+back] is the lexical value, whereas [-back] is the lexical value in language B. In single-valued feature approaches, this situation is completely different, since these only employ the "feature" [i] indicating palatality or frontness.

Coalescence in language B would imply the merger of the privatives [i], [u] (= roundness) and [a] (= height). In language A, on the other hand, coalescence cannot be described as a feature-fusion phenomenon, because we have to delete [i] first, and only after this change is accomplished can we merge all remaining privatives. Hence, coalescence in language B conforms to Schane's (1984a) claim that the output of fusion contains all and only the particles of the input, while language A refutes this claim. In Schane's theory VC languages like language B are expected not to exist. It is striking that one and the same phenomenon, applying under identical circumstances (cf. De Haas 1987a and ch.5 below) cannot be formally described in a uniform fashion. In nearly all languages, coalescence would comprise both feature deletion and fusion of privatives. In a binary-feature theory, languages may differ in the values that are taken as the lexical or as the redundant values, and as a consequence vowel coalescence can be characterized as a phenomenon by which nondistinct feature matrices are merged into one shared matrix.

From the discussion above one should not conclude that single-valued features must be ruled out in principle. On the contrary, the theory of feature geometry is basically a theory in which single-valued features play an important role. Sagey (1986b), for instance, argues that the features [labial] and [coronal] are not binary. In her model, these features are single-valued articulator nodes. Similarly, all the class nodes posited in the geometry framework are single-valued by definition. Recall our discussion of the interdependence of the laryngeal features in section 1.1.3.2, where we have argued that the laryngeal features [voice], [spread] and [constricted] are not the terminal nodes in the geometry. We have claimed that these features are contained within the laryngeal node. As a result, our laryngeal node is a single-valued feature, in the same way as [coronal] and [labial] are.

Two arguments have been given to illustrate that D-values are of theoretical relevance in phonology. In the first place, it has been shown that languages may differ in the properties of long-distance phenomena. In particular languages, D-values may act as blockers (Latin) or initiators of a new spreading domain (Barra Gaelic), whereas in other languages they are transparent (Japanese). Hence, D-values can have a crucial effect on the scope of long-distance assimilation or dissimilation. Secondly, it has been shown that languages may differ with respect to which feature values are taken as lexical. It turned out that vowel coalescence may result in front vowels in one language and in back vowels in others. If we want to maintain the claim that coalescence must be conceived as the merger of nondistinct vocalic segments, we need the power of a binary-feature system. Otherwise, we would not be able to describe the coalescence phenomena in the two language types by one and the same format.

1.3 Inalterability and the Linking Constraint

Hayes (1986a) and Schein and Steriade (1986) discuss the well-known observation that long vowels and consonants frequently resist the application of rules that would - a priori - be expected to apply to them. This property of geminates is usually referred to as inalterability or geminate blockage. CV Phonology cannot by itself account for this behavior of geminates. Hayes claims that with some minor adjustments, particularly by the introduction of the Linking Constraint, CV theory can handle the inalterability problem.

Two types of P-rules need to be distinguished: those that take both short and long segments as their input, and those that only apply to short segments. An example of the latter type is spirantization in Tigrinya, a Semitic language spoken in Eritrea (cf. Schein 1981, Kenstowicz 1982). After a vowel, the velar stops /k, g, k'/ are produced as the corresponding fricatives:

(90)	a: kʌlbi	'dog'(sg.)	b:	?axalɨb	'dog'(pl.)
	gʌn?i	'pitch'(sg.)		?aγanɨ?	'pitch'(pl.)
	k'ʌbʌrʌ	'to bury'		yɨx'ʌbbɨr	'he buries'

Spirantization must refer to the CV skeleton to identify a postvocalic position, and to the melody to constrain application to velar stops. Hayes states the rule as follows:

(91) **Tigrinya Spirantization:** (Hayes 1986a:336)

$$\begin{bmatrix}-\text{son}\\+\text{bck}\end{bmatrix} \rightarrow [+\text{cont}] \;/\; \begin{array}{cc} V & C \\ & | \\ & \_\_ \end{array}$$

Unexpectedly, spirantization fails to affect underlying geminate velars. Moreover, it does not apply to geminate /kk/ resulting from a complete assimilation rule. However, if /kk/ is the immediate result of morpheme concatenation, the rule applies. The relevant forms are given in (92):

(92) a: fʌkkʌrʌ	→ *fʌxxʌrʌ		'he boasted'
b: yɨ-t-kʌfʌt	→ yɨkkʌfʌt	→ *yɨxxʌfʌt	'open-passive-jussive'
c: mɨrak-ka	→ miraxka		'calf-2.sg.masc.'

In CV Phonology, the representations of the forms in (92) are crucially different. Schematic derivations are given below:

(93) a: V C C (92a)   b: V C+C (92b)   c: V C+C (92c)

$$\begin{array}{ccc} \text{a:}\ \mathrm{V\ C\ C} & \text{b:}\ \mathrm{V\ C{+}C} & \text{c:}\ \mathrm{V\ C{+}C} \\ \mathrm{k} & \mathrm{t\ k} & \mathrm{k\ \ k} \\ \downarrow & \downarrow & \downarrow \\ {}^{*}\mathrm{x} & {}^{*}\mathrm{x} & \mathrm{x} \end{array}$$

An example of the first type is palatalization in LuGanda (cf. Clements 1986a). This rule optionally changes the consonants /k, g/ into the corresponding palatals before /i, y/. The last form in (94) shows that this rule applies irrespective of the length of the velar:

(94) kiintu - čiintu 'thing'
bwoogi - bwooǰi 'sharpness'
oluggi - oluǰǰi 'door'

In order to capture the observation that both /i/ and /y/ cause palatalization of preceding velars, we must explicitly avoid reference to the CV-skeleton in the structural description. LuGanda palatalization is formalized in (95):

(95) LuGanda Palatalization: (Hayes 1986a:343)

$$\begin{bmatrix} -\text{son} \\ -\text{cont} \\ -\text{ant} \\ -\text{cor} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{back} \\ +\text{cor} \\ +\text{stri} \end{bmatrix} \ / \ \underline{\quad} \begin{bmatrix} -\text{cons} \\ +\text{high} \\ -\text{back} \end{bmatrix}$$

According to Hayes, the following generalization emerges from the two examples above: roughly speaking, if a P-rule mentions both the CV-skeleton and the melody in its structural description, the rule is subject to inalterability or geminate blockage; but if it refers to one tier only, the rule escapes inalterability. He argues that the dependence of inalterability on the number of tiers mentioned in the formulation of the rule does not need to be stipulated, but follows naturally from independent principles. He claims that two-tier rules or structure-dependent rules are special in that they include association lines in their structural description.

"Suppose that some phonological rule P contains in its structural description autosegments α and β, linked by an association line, as in (24a). Suppose further a representation R, which contains the autosegments A and B, A is an autosegment analysable by α...; and B is an autosegment analysable by β. The crucial question is: What association lines should be present in representation R in order for rule P to apply to it? Two logical possibilities exist. (a) First, we might suppose that P is applicable to R, if A is linked AT LEAST to B, where A and B may also be linked to other autosegments. Under this interpretation, P may apply to any of the candidates for R under (24c):

```
(24) a: Rule P contains α
                        |
                        β
     b: A 'is an' α.
        B 'is an' β.
     c: Possibilities for representation R
        (i) x A x    (ii) x A      (iii) x A x    (iv) x A
            | | |         | |\           | |/           \|\
            x B x         x B x          x B              B x
```

(b) The other possible interpretation is that rule P applies to R only if A is UNIQUELY linked to B, and vice versa. If this is true P would apply only to representation 24c(i)." (1986a:330-1)

Hayes concludes that only empirical facts can determine to which representation R rule P may or may not apply. The large number of languages investigated seems to indicate that the second possibility is the correct one. To account for this restriction Hayes proposes the universal Linking Constraint (96):

(96) Linking Constraint:(LC)
Association lines in structural descriptions are interpreted as exhaustive.

The rule of spirantization in Tigrinya contains one association line between the CV tier and the melody, and should therefore not be able to apply to true geminates, nor to geminates derived by complete assimilation, since the features [-son, +back] are linked to two skeleton slots in these representations. The association lines in (91) cannot be interpreted as exhaustive for these forms. The rule of palatalization in LuGanda does not mention any association line in its formulation, and both simple and geminate velars can become palatalized.

Schein and Steriade (1986) approach inalterability or geminate blockage from a slightly different perspective. In Hayes' account the LC is a condition that interprets the relation tier A is associated to tier B as tier A is exclusively associated to tier B, and vice versa. Schein and Steriade, on the other hand, claim that the applicability of a rule to multiply linked autosegments can always be predicted from the way the rule must be formulated. Consider the representations in (97):

```
(97) a    x        b:   x        tier A
          |            / \
          y           y   z      tier B
```

They claim that if the SD of some rule affecting x imposes conditions that are met by y but not by z, then the rule will not apply to multiply linked structures like (97b). However, if the rule changes x on tier A and no conditions are imposed on the elements of tier B, immediately dominated by tier A, then the rule will apply to all structures fulfilling the SD, irrespective of the fact whether they are singly linked or multiply linked. Schein and Steriade's proposal is largely compatible with that of Hayes (1986a), and therefore we will take the liberty to hold on to Hayes'.

In the remainder of this section, we will extend the scope of the LC to other structure-dependent rule types. First, we will discuss a proposal by Itô (1986), who proposes to include the phenomenon of syllabification. Next, we will argue that the LC is also applicable to segment-internal structure-dependent rules.

1.3.1 Syllabification

Static syllable constraints can be stated in two ways. Suppose that in a given language syllables can end in a sonorant consonant, but not in an obstruent. This observation can be described by means of a negative condition which excludes [-son] consonants in coda position, or by means of an adjunction rule which adjoins a [+son] consonant to the preceding syllable. These possibilities are represented in (98):

```
(98) a: Coda condition          b: Coda rule
          *C]o                        o
           |                          |\
        [-son]                        X C
                                        |
                                      [+son]
```

According to Itô (1986), the option exemplified in (98a) is preferable. The evidence is based upon the claim that the well-formedness of prosodic structure must be determined locally. More specifically, a condition imposed on syllable structure can only refer to the syllable, but not to a sequence of syllables or a sequence of skeleton slots. Thus, she considers conditions such as those in (99) undesirable:

(99) a: An obstruent can be the final element in a syllable only if the following syllable starts with an identical obstruent.

b: An obstruent can be syllabified as a coda, if it is segmentally linked to the following C.

However, nonlocal information such as expressed in (99) would seem to be required in order to define the phonotactic structure of languages like Japanese or Italian. In Japanese the following situation exists:

(100) a:	ka.mi.ka.ze	'divine wind'	b: *kap.toot
	kai.soo	'sea weed'	*sek.pa
	sen.see	'teacher'	*kap.sek
	sek.ken	'soap'	
	tos.sa	'impulsively'	("." indicates syllable boundary)

We observe that syllables may end in a short vowel, a long vowel, or a diphthong. In addition, a syllable may be closed by a nasal consonant or by the first half of a geminate. In a rule-based theory of syllabification, we must assume a coda rule of the type in (101):

(101) Japanese coda rule:

```
        σ                if a, then b
        |\
        V  C  C
            \/ b
        <[-nas]>a
```

Such a coda rule has at least two disadvantages. It makes crucial use of nonlocal information, and it is an abbreviation of two subrules of which it is unclear what they share (the angled-bracket notation indicates that two rules have been collapsed). Itô argues that we can express the observations in (100) quite nicely in a condition-based syllable theory, if we assume that the LC also holds here. If association lines mentioned in syllable conditions must be interpreted exhaustively, it suffices to posit the coda condition (102):

(102) Japanese coda condition:

```
        * C]σ
          |
        [-nas]
```

This condition states that a nonnasal consonant cannot occur syllable-finally. The fact that the first half of a geminate obstruent is allowed in this position follows from the LC. In a geminate, [-nas] is linked to two consecutive skeleton slots, and therefore immune to condition (102).

A similar situation exists in Italian (cf. Vogel 1977). The basic facts are as below:

(103) a: in.flessibile 'inflexible' b: lab.bro 'lip'
al.tro 'other' ap.plaudire 'applaud'
bur.gravio 'castle lord' elet.trico 'electric'
es.pres.so 'express' ag.glomerare 'agglomerate'
c: *it.flessibile, *ap.tro, *bud.gravio, *eg.blema, *ec.presso

In Italian, sonorant consonants and /s/ are allowed in syllable-final position. Moreover, the first half of a geminate is allowed in this position, whereas the short stop is not. If we interpret the coda condition (104) in accordance with the LC, we can handle these facts in a straightforward way:

(104) Italian coda condition:

```
        * C]σ
          |
        [-son ]
        [-cont]
```

Since [-son,-cont] is associated to two C-slots, the coda condition in (104) will not rule out the syllabification of the first half of a geminate.[12]

1.3.2 Segment-internal branchingness

Hayes (1986a) and Schein and Steriade (1986) distinguish between structure-dependent rules and segmental rules. The latter type requires only segmental information, and does not refer to the CV tier or the syllabic organization. However, the segmental melody is also hierarchically organized: distinctive features cluster together in larger constituents and have all kinds of dependency relations. As a consequence, the relations between the CV tier and the melody resemble those among segment-internal constituents. In (97), we gave a schematic representation of doubly-linked and singly-linked autosegments. This general format allows several interpretations. Some of these are stated in (105):

(105) a: C   C C   C   skeleton   b: pl   pl   pl pl
t   t   t s   melody   dors   lab dors   dors

The interesting question is whether the LC holds for segment-internal structure-dependent rules. In a theory of full specification, the answer must be negative as will become clear immediately below. In a theory of underspecification, on the other hand, representations can differ in the amount of features and/or nodes present. This enables us to investigate whether a difference in the number of nodes dominated by a superordinate node influences the application of phonological rules. If this indeed turns out to be relevant, we can take it as additional evidence in favor of the theory of underspecification outlined in section 1.2.

In (106) below, we provide the relevant part of the representation of the vowels /i, e/ in both a full specification framework and an underspecification framework. Suppose the language has a rule of palatalization in which an obstruent is palatalized if it is followed by /i, y/ (e.g. LuGanda). In a theory of full specification, we cannot invoke the LC to exempt the /e/ from triggering palatalization. In the representation of /i/ as well as the representation of /e/ the dorsal node branches. In a theory of underspecification, the representations of /i/ and /e/ are crucially different with respect to the number of branches.

(106) a: Full specification   b: Underspecification
dors   dors   dors   dors
[+hi] [-bck]   [-hi] [-bck]   [-bck]   [-hi] [-bck]
[i]   [e]   [i]   [e]

If palatalization is restricted to /i, y/ the rule of palatalization can be stated in such a way (cf. (107) below) that the rule itself expresses the difference between the front unrounded vowels:

(107) *   *   dorsal   where an associating line terminated by X indicates 'no association'
[-bck]

This formalization implies that spreading of [-back] will take place if and only if the dorsal node is exclusively linked to the [back] tier. Hayes (1986a) shows that rules like (107) would also be necessary in theories which do not invoke the Linking Constraint to account for geminate blockage. It therefore seems reasonable to exclude rules like

(107) from phonological theory entirely, and to derive the effects of such a formalism from an interpretation convention such as the Linking Constraint.

In the succeeding pages, we will present evidence which shows that the number of association lines present in the structural description of phonological processes must be interpreted as exhaustive, even for segment-internal structure-dependent rules. We will also return to the problem of giving content to the notion of 'natural class' in a theory of underspecification, and suggest that the theories of tier decomposition and underspecification, and the extension of the LC in the way suggested above, allow us to derive the notion of natural class from the hierarchical representation of distinctive features and the nonlinear formalization of phonological rules.

We will begin our investigation of the relevance of the LC for segment-internal rules by looking at some well-known empirical observations, on palatalization, degemination and metathesis of quantity, respectively.

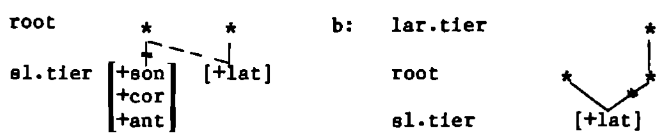
(a) Palatalization. Languages differ in the sets of sounds which trigger palatalization. In Gallo-Romance (cf. Jacobs forthcoming) all front unrounded vowels/glides trigger palatalization and sometimes subsequent affricatization of a preceding consonant. In many other languages, however, only the high front vowel/glide trigger palatalization. Hence, we have to explain why all front vowels constitute a natural class in Gallo-Romance, whereas they do not in e.g. LuGanda.

(b) Degemination. In Klamath (cf. Barker 1964, Clements 1985) the following set of changes is of particular interest:

(108) nl	→ ll	/honlīna/	→ hollīna	'flies along the bank'
nl̥	→ lh	/honl̥y/	→ holhi	'flies into'
nl'	→ l?	/honl'āl'a/	→ hol?āl'a	'flies into the fire'
ll̥	→ lh	/pāll̥a/	→ pālha	'dries on'
ll'	→ l?	/yalyall'i/	→ yalyal?i	'clear'

We observe that the supralaryngeal features of /l/ spread backward onto /l, n/ and furthermore, that the supralaryngeal features of /l̥, l'/ are dissociated. Clements (1985) proposes the following rules to account for the changes:

(109) a: b:

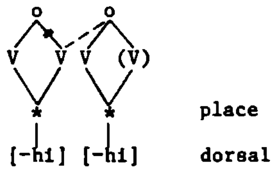


The problem is why underlying and derived sequences /ll̥/ and /ll'/ undergo (109b), whereas the plain geminate /ll/ does not.

(c) Metathesis of Quantity. In the Ionic-Attic dialect the underlying sequences /ɛ̄a, ɛ̄o, āo, ɛ̄ɛ̄, āɔ̄, ɛ̄ɔ̄, āō/ undergo a change into [eā, eɛ̄, eɔ̄] (cf. Wetzels 1986, section 3.4 below). Thus a long [-high, -round] vowel is shortened with subsequent lengthening and laxing of the following [-high] vowel. In chapter 3, we will argue that Metathesis of

Quantity can be stated as in (110):

(110) Metathesis of Quantity: (MQ)



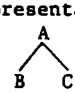
Apparently, the specification [-high] is insufficient, since it defines the class /ɛ̄, ā, ɔ̄/. However, /ɔ̄/ does not trigger MQ. It seems that, in order to exclude /ɔ̄/, the structural description of MQ must mention the feature [-round]. In chapter 3, it will be argued that [-round] is a D-value, which we expect to be irrelevant at an early stage in the derivation.

Below, we will show that the processes under (a) through (c) can be accounted for if we assume that the LC also holds for segment-internal structure-dependent P-rules. Before we will illustrate how this can be achieved, we must first introduce some additional notions.

Hayes assumes that a rule P that refers to the autosegments A and B, linked by an association line will only apply to a representation R if (i) autosegment A is exclusively linked to autosegment B, and (ii) autosegment B is exclusively linked to autosegment A. Since the autosegments A and B themselves are usually components of further hierarchical structure, we have to define what is meant by 'exclusively linked to'. Suppose a representation R, in which the autosegment A is linked to the autosegments B and C, where C dominates A and A dominates B. Suppose furthermore a representation S, in which the autosegment A is linked to the autosegments C and D, where A dominates both C and D:

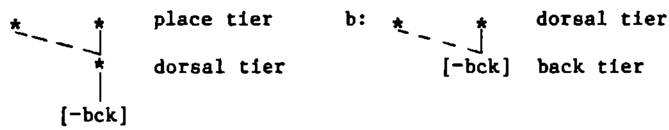
(111) a: Representation R

b: Representation S

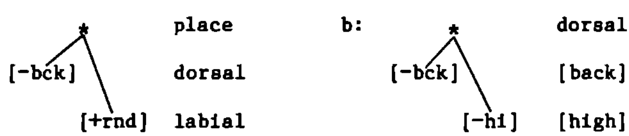


The crucial issue here is whether the representations R and S are identical for the notion of 'exclusively linked to'. The discussion in Hayes (1986a, b) and Schein and Steriade (1986) shows that this should not be the case. In order to be able to distinguish between representations like R and S, we will introduce the notions of head and operator. A head is an autosegment immediately dominating another autosegment, and an operator is an autosegment immediately dominated by another autosegment. By introducing the notions of head and operator we can distinguish between the representations R and S with respect to the phonological rule P. If the autosegments A and B referred to in the rule P are head and operator, respectively, the rule will apply to a given representation, if the head (A) is exclusively linked to a single operator (B) and the operator is exclusively linked to a single head. Under this interpretation rule P will apply to representation S, while it will be blocked in the case of representation R, since in the latter case the head is linked to two operators. Below, we will assume that this interpretation of the Linking Constraint is correct.[13]

The phenomenon of palatalization can take at least two different forms. We can either state it as the spreading of the dorsal node which contains [-back], or as the spreading of the feature [-back]. Both possibilities are represented in (112):

(112) a:


Given the theory of underspecification, the theory of tier decomposition and the LC, we make different predictions with respect to the segmental classes which can trigger the rule. The rule in (112a) mentions one association line between the place node (head) and the dorsal node (operator). If this association line is the sole association between these autosegments, we predict that segments characterized as in (113a) below cannot act as triggers. The formulation in (112b) mentions one association line between the dorsal node (head) and the [back] tier (operator). By the same token, we expect that representations like (113b) will not be able to trigger palatalization:

(113) a:


If we assume that the palatalization rule (112a) is correct for Gallo-Romance[14], we predict that all [-back] vowels act as triggers, unless they are specified as [+round]. Hence, from the set of front vowels, /i, e, ä/ can change a preceding obstruent into a palatal. If we furthermore assume that palatalization in LuGanda is of the (112b) type, we predict that from the set of [-back] vowels only /i/ can activate the rule, if /e/ is represented as in (113b). Thus, the observation that the [-back, -round] vowels act as a natural class in Gallo-Romance, whereas they do not in LuGanda can be accounted for if we assume slightly different palatalization rules for these languages, and if the LC holds for all structure-dependent rules.

The fact that the [-high] vowels bar /ɔ̄/ constitute a natural class for MQ in Ionic-Attic can be accounted for in a similar fashion.[15] The representations of /ɛ̄/ and /ā/ contain one association line between the place tier (head) and the dorsal tier (operator), whereas the representation of /ɔ̄/ contains one additional association line between the labial (operator) and the place node (head). The differences between /ɛ̄, ā, ɔ̄/ are as in (114):

(114)	a: *	b: *	c: *	place
	[-hi]	[-hi +bck]	[-hi]	dorsal
			[+rnd]	labial
	[ε̄]	[ā]	[ɔ̄]	

If we invoke the LC , we can maintain the formulation of MQ in (110) which does not refer to the feature [-round].

In the preceding section we considered a potential disadvantage of underspecification theory: the expression of natural classes of sounds for the application of phonological rules. In Ancient Greek, [-round] is a D-value which is unspecified underlyingly. Consequently, the class of [-high, -round] vowels cannot be referred to. However, if we take into account the hierarchical organization of features and the LC which interprets association lines mentioned in the structural description of a rule, we can derive the natural class of [-high, -round] vowels in an indirect way. The [-high, -round] vowels consist of a single association line between the place node and the dorsal node, while the [-high, +round] vowels have an additional association line between the place node and the labial node. Hence, these two natural classes differ in the number of association lines present in their feature geometry, and the LC will ensure that this difference is interpreted in the correct way.

Essentially, the same procedure can be followed for LuGanda and Gallo-Romance, where UT does not allow us to make reference to the class of [-back, -round] vowels and the set of [+high, -back] vowels, respectively. However, in these languages the classes of [-back, -round] vowels (Gallo-Romance), or [+high, -back] vowels (LuGanda) differ from their [-back, +round], [-high, -back] counterparts in the number of association lines present in the feature geometry. Again, the LC will interpret this distinction in such a way that we can derive the classes of front unrounded and front high vowels in an indirect way.

The Klamath example is just the opposite. All sonorants and obstruents fall into three categories: plain, glottalized, and aspirated. In a theory of full specification, degemination rule (109b) cannot be maintained. Since plain geminates remain unaffected by this rule, we would have to stipulate that degemination only takes place if the lateral is [+spread] or [+constricted]. In the version of UT proposed here [-constricted] and [-spread] are the R-values, the 'plain' lateral is therefore fully unspecified for the laryngeal features, and as a consequence the root node is nonbranching. If association lines must be interpreted as exhaustive, we predict that lateral degemination (109b) will not apply to plain geminate /ll/s. The Klamath forms in (108) show that this prediction is correct.

In summary, we have shown that UT allows us to extend the scope of the LC beyond its original domain of application. We have argued that this condition holds for all structure-dependent rules. Hence, we have brought forward additional evidence in favor of underspecification theory. In addition, it turned out that the LC enables us to refer to natural classes of sounds, to which we cannot possibly refer by way of UT itself. Thus, by broadening the domain of application of the LC, we counter a possibly important argument against underspecification theory.

1.4 Lexical Phonology and the Strict Cycle Condition

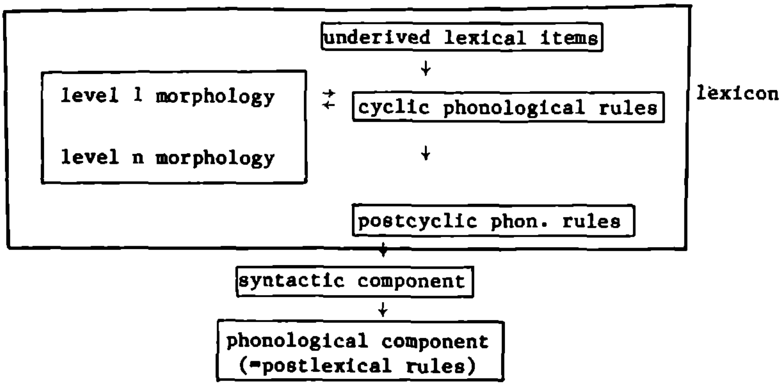
In this section, we will discuss two proposals for eliminating the Strict Cycle Condition (henceforth SCC) from phonological theory. Kiparsky (1982) argues that given the theory of underspecification, the effects of the SCC can be derived from the Elsewhere Condition. Hermans (1986, forthcoming) argues that the effects of the SCC can be obtained from the Projection Principle, again under the assumption of underspecification theory. If the attempts in Kiparsky (1982) and Hermans (1986, forthcoming) are correct, we have a further theory-internal argument for the theory of underspecification. Both proposals rely upon the theory of Lexical Phonology, and we will therefore briefly outline the essentials of this theory, before we enter into the discussion of the SCC.

Lexical Phonology is still very much in the process of development, and there is no consensus with regard to the details of lexical organization among the linguists who have been actively concerned with its development. Recent literature shows a considerable variety of different proposals, and it is not our purpose to add a new version. We will simply present a brief outline of the most influential proposals, such as Kiparsky (1985), Halle and Mohanan (1985) and Booij and Rubach (1987), which defend the idea that the lexicon (morphology and lexical phonology) is autonomous from syntax.[16]

The theory of Lexical Phonology (cf. Pesetsky 1979, Kiparsky 1982, Mohanan 1982, and the above references) adopts from Siegel (1974), Aronoff (1976)..etc. the idea that the word-formation rules are level-ordered, in that derivational and inflectional processes are organized in a sequence of levels or strata. Moreover, each level is associated with a set of phonological rules, that is, the output of a word-formation rule is submitted to the phonological rules of its level. According to Kiparsky (1982) this establishes a basic division among phonological processes into lexical rules which apply within the lexicon, and postlexical rules which take syntactic S-structures as their input. The former rules are intrinsically cyclic, since they reapply after each word-formation rule, whereas the postlexical rules are intrinsically noncyclic.

Booij and Rubach (1987) argue for a refinement of the model proposed by Kiparsky (1982). They claim that the lexical rules can be further divided into cyclic lexical rules and postcyclic lexical rules. The cyclic rules are interspersed with morphology, whereas the postcyclic rules apply after the cyclic phonological rules and by inclusion also after the word-formation rules, though still within the lexicon. The basic model they propose is given in (115):

(115)



As an example, consider the fact that in English, affixes fall into the stratum-1 affixes like -ic, -ion, -ity and in-.., and the stratum-2 affixes such as -ness, -hood and un-. In addition, the cyclic rule of Trisyllabic Shortening or Trisyllabic Laxing is assigned to stratum-1 (e.g. divine - divinity, serene - serenity, declare - declarative), and therefore does not apply to forms such as maidenhood, timeliness..etc., because these words are formed at stratum-2. Furthermore, underived lexical items like nightingale, ivory, stevedore do not undergo the rule, since cyclic rules do not apply to underived forms because of the Strict Cycle Condition.

The class of cyclic rules appears to be distinguished from the non-cyclic rules by a conglomerate of properties. Cyclic rules apply word-internally only; they are morphology-sensitive; they may have lexical exceptions, they may feed morphological word-formation rules; they are structure-preserving, which is related to the concept of 'neutralization'; they can be blocked by other cyclic rules by means of the Elsewhere Condition, and they operate all and only in derived environments. Especially the property of structure-preservingness and the restriction to derived environments have puzzled many linguists during the past decade or so. Mascaro (1976) proposes that the class of cyclic rules be identified as the class of rules which exhibit the "derived-environment-only" constraint, and he proposes that the Strict Cycle Condition account for this. A simplified version of this constraint is given in (116):

(116) Strict Cycle Condition: (SCC)

a. Cyclic rules apply only to derived representations.

b. Def.: A representation ϕ is derived w.r.t. rule R in cycle j iff (i) ϕ meets the structural description of R by virtue of a combination of morphemes introduced in cycle j.

(ii) or the application of a phonological rule in cycle j.

(Kiparsky 1982:41)

However, Kiparsky (1982) notices that the SCC is far from unproblematic. First, the (strict) cyclic application of movement rules in syntax probably does not have to be stipulated as an independent principle in the theory, because its effects can be derived from other principles, in particular the 'opacity' conditions. If this is correct, it would be surprising if the SCC were a primitive in phonology. Second, there are several empirical problems for the SCC. For example, lexical stress in English must be assigned cyclically and therefore we expect 'strict cyclic' properties of stress. However, the English stress rule must apply to underived lexical items on the first cycle. In Lithuanian, on the other hand, the stress rule obeys the SCC, that is, underived lexical items are exempt from undergoing the cyclic stress rule. In addition, the rule of Trisyllabic Shortening is a cyclic rule. However, most underived forms exhibit the same properties as derived forms which have undergone the rule (e.g. alibi, sycamore, Pamela, calender). At face value, two possible derivations can account for these facts: we can assume that the vowel of the first syllable is short underlyingly, or we can derive the short vowel from an underlying long vowel and apply Trisyllabic Shortening as a 'morpheme-structure rule'.

Kiparsky (1982) argues that the SCC is not a primitive in phonology, and he suggests that a version of the SCC is deducible from the Elsewhere Condition if it is assumed that all lexical entries undergo a so-called identity rule. For example, the form nightingale undergoes an identity rule whose output is $/\text{nightingale}/_N$. This will block the application of Trisyllabic Shortening, since the identity rule and Trisyllabic Shortening are in an elsewhere relation (the identity rule properly includes Trisyllabic Shortening and the outputs of the rules are distinct, since the first vowel of nightingale remains long in the identity rule but would become short by Trisyllabic Shortening). The notion of identity rule itself, however, is not unproblematic (cf. Mohanan 1982), and probably for this reason Kiparsky abandoned this idea, and returned to the SCC in subsequent work (cf. Kiparsky 1985).

Like Kiparsky (1982), Hermans (1986, forthcoming) attempts to derive the SCC from independently motivated principles. He argues that the properties of this constraint can be derived from an extended version of Chomsky's (1981:29) Projection Principle (117):

(117) Projection Principle: (PP)
Representations at each syntactic level (i.e. LF, and D- and S-structure) are projected from the lexicon, in that they observe the subcategorization properties of lexical items.

Generally speaking, the PP can be regarded as a principle that disallows syntactic representations of a grammatical category which do not match its lexical subcategorization. Hermans proposes to extend the domain of the PP to the lexicon itself, that is, not only the syntactic properties but also the phonological properties of a lexical item are conditioned by the PP. He also assumes that this principle is a condition on both representations and on the application of rules. A rule may apply to a particular representation if it does not neutralize a lexical contrast, and does not render distinct its input and its output: otherwise the rule will be blocked by the PP. If it is assumed that after each level or stratum in the lexicon the forms derived at that level are interpreted as lexical items, and are added to the vocabulary up to that level, each level comprises its own vocabulary. For example, in English stress is unspecified underlyingly, and therefore the "feature" [stress] does not belong to the underlying vocabulary. Stress is assigned at stratum-1, and consequently the feature [stress] is added to the vocabulary of all subsequent levels.

Morphological concatenations on a particular level do not constitute a lexical item and, as a consequence, are not conditioned by the PP. For example, the application of Trisyllabic Shortening can apply to the word opacity, because the input /ōpēk+ity/ is not a lexical item (though the output opacity and the stem opaque are). Thus the lexical items opacity and opaque are conditioned by the PP, whereas /ōpēk+ity/ is not. On the other hand, underived lexical items, when they enter level 1, are within the reach of PP. This predicts that cyclic rules can apply to these underived lexical items under strict conditions, namely if and only if (i) the input and output of the rule are nondistinct, and (ii) the rule does not destroy/neutralize underlying contrasts, that is, the application of cyclic lexical rules is allowed in nonderived environments if and only if they are nonstructure changing. If a rule renders input and output distinct or if it neutralizes a contrast between lexical items, its application is restricted to derived forms.

We will illustrate the consequences of Hermans' proposal for English and Lithuanian stress. Since in English stress is to a large extent predictable, it can be left unspecified in underlying representation. Hence, the "feature" [stress] does not belong to the phonological vocabulary of level 1. As a consequence, the English stress rule can apply to underived forms such as parent, since the input form (/parent/$_N$) and the output ((pa)$_s$(rent)$_w$) are nondistinct. Moreover, the rule does not neutralize a contrast between items that are lexically specified for stress and items that lack such a specification. The Lithuanian case is totally different. Stress is assigned lexically to the class A roots and affixes (e.g. ránk 'hand', -óm dat.fem.dual), but it is predictable for the class B roots and affixes (e.g. galv 'head', -ai dat.fem.sg.). The addition of -óm results in different stress patterns depending on whether the root belongs to class A or to class B: ránkom but galvóm (stress is realized as a falling or rising tone in Lithuanian, a fact which will be ignored here). The stress rule of Lithuanian assigns word stress to the leftmost syllable bearing a lexical stress marker. If there is no underlying stress, the first syllable receives word stress. Hermans (1986) shows that stress must be assigned cyclically in Lithuanian. But, unlike the English rule, the Lithuanian stress rule does not apply to underived lexical items. The reason for this is that the contrast between class A and class B forms would become neutralized. We would incorrectly predict ránkom and *gálvom as is shown in (118):

```
(118) a:   *           b:                 First Cycle
           *
         [rank]         [galv]

                          *
                          *
           n.a.         [galv]            stress rule

           *   *          *   *           Second Cycle
           *   *          *   *
         [[rank]om]     [[galv]om]
           *              *
           *   *          *   *
           *   *          *   *
         [[rank]om]     [[galv]om]        word stress

          [ránkom]      *[gálvom]
```

The neutralizing effect that would result from the application of the stress rule must be blocked. Hermans argues that his extended version of the PP enables us to account for this fact. At the level where the stress rule applies in Lithuanian zero stress (class B) and presence of stress (class A) are distinct. Given the PP, zero stress and stress must remain distinct at all subsequent levels. The stress rule therefore cannot affect underived lexical items, since that would imply a neutralization of an existing distinction.

Summarizing, in this section we have outlined one of the recent versions of Lexical Phonology. Following this proposal three major classes of phonological rules are distinguished: cyclic lexical rules, postcyclic lexical rules and postlexical rules. Furthermore, we have presented the proposals by Kiparsky (1982) and Hermans (1986), who argue that the SCC can be eliminated from phonological theory, and derive its effects from independent principles. Both proposals have in common that the theory of underspecification is crucial. Hence, if they are correct, the elimination of the SCC presents further support for the theory of underspecification advanced in this thesis.

Footnotes

1: Cf. chapter nine in SPE for the first attempt to solve the markedness problem raised here. We will not go into the specific details of markedness theory, since in nonlinear phonology the relative markedness of phonological rules can be inferred from feature-geometry theory, according to which features are hierarchically organized under superordinate class nodes such as 'laryngeal' and 'place of articulation'.

2: In this thesis, we will use capitals in the following way. "P", "T" and "K" stand for, respectively, labial, coronal or velar stops unspecified for the laryngeal and nasal features. "N" indicates a nasal unspecified for place.

3: The underlying form is /budh/. However, under particular conditions which are irrelevant for the present discussion, /a/ or /ā/ is inserted in this root. Furthermore, the vowel sequence /a+u/ is subject to merger by vowel coalescence, and shows up phonetically as [ō].

4: Two often cited exceptions to the claim that feature permutations do not occur in speech errors are pig and vat for big and fat (voice reversal) and spattergrain for scatterbrain (place reversal) (cf. Fromkin 1973, 1975).

5: Yip (1982) assumes that the secret language is generated at some level intermediate between underlying forms and the phonetic surface, probably after the application of the lexical phonological rules. However, she does not present evidence to support this assumption. In the absence of such evidence, I maintain the claim that this secret language takes underlying forms as its input.

6: The SFC is probably a subcase of the Obligatory Contour Principle. Another subcase of this general principle is the Nuclear Fusion Principle proposed by Wetzels (1986), and modified by De Haas (1986b). The functioning of a rule of schwa epenthesis in Dutch allows us to show that the major class features are also exempted from undergoing this fusion principle. Schwa epenthesis splits up consonant sequences whose members do not share one or more features. Words like arm 'arm' do undergo schwa epenthesis. If the major-class features [+son, +cons] are subject to the NuFuP, it is incorrectly predicted that schwa epenthesis cannot occur in clusters of two sonorant consonants. By exempting the MCFs from the NuFuP, the alternation [arm] ~ [arəm] can be accounted for (for details cf. De Haas 1986b, 1987b).

7: By extending the scope of the SFC, we follow a suggestion by Clements (1985). A similar view can be found in Sagey (1986b).

8: We are indebted to Nick Clements for fruitful discussions concerning the issues raised here. The following discussion draws heavily upon his 1986/1987 Cornell class notes "Underspecification: Pro and Con". Of course, he should not be held responsible for possible misinterpretations of these notes.

9: Cf. Kiparsky (1982) for a detailed discussion of the "empirical" problems raised by Stanley (1967).

10: Actually, Clements (1981) deserves the credit for reintroducing underspecification in autosegmental phonology. He argues, with respect to vowel harmony in Akan and Turkish, that the target vowels for the rule of vowel harmony are unspecified for the harmonizing feature. For example, in Akan, the value for the harmonizing feature [ATR] is contextually determined. In broad outline, if the stem vowels are [αATR], the affix vowels will also be [αATR]. Hence, the feature [ATR] is nondistinctive in affixes, and Clements decides to leave [ATR] unspecified to avoid the arbitrary choice of specifying them as either [+ATR] or [-ATR] in the lexicon.

11: The notion 'distinct' is used in the sense of Halle (1959) and SPE: two segments A and B are distinct if there is at least one feature [F] which is specified as "a" for A and "-a" for B (where "a" = "+" or "-").

12: The Coda Condition (104) incorrectly allows for syllables ending in /f/. The alternation between scrivere (inf.) and scritto (past part.) 'write' shows that syllable-final /f/ is ruled out. It appears that an additional coda constraint must be posited for /f/.

13: We will leave the formalization of the ideas presented here for future research, since this would take us too far beyond the main topic of this thesis.

14: We assume for both Gallo-Romance and LuGanda that [-high], [-back] and [+round] are the lexical values.

15: In chapter 3, it will turn out that [+high], [+back] and [+round] are the lexical values in Attic. MQ refers to [-high] in its formalization, which entails that the D-rule supplying this value must apply prior to MQ as is stipulated by the RROC.

16: For different proposals cf. Baker (1985), Sproat (1985) and Halle (1987).

2.0 Introduction

It is a well-known observation that languages tend to avoid vowels in hiatus, i.e. vowels at the borderline of two adjacent syllables. Since vowels are the most sonorous segments in the syllable, vocalic hiatus can be regarded as a sonority clash.

Many linguists have noted the existence of cross-linguistic preferences for particular types of syllable sequences and syllable structures (cf. Hooper 1976, Murray and Vennemann 1983 and Clements 1987b). It is observed that the sonority strength of two contiguous segments plays an important role. For example, tautosyllabic geminate consonants and tautosyllabic consonant clusters where the members have identical sonority strength are not allowed in many languages. Linguists differ in the way they account for these observations, but among the notions which often recur are 'sonority hierarchy', 'minimal sonority distance' and 'bad syllable contact'. In particular, the notion of 'bad syllable contact' and Hooper's Syllable Contact Law seem to play an important role, since it appears that sequences of two segments which are too close in sonority tend to be eliminated by the application of phonological rules. Hooper (1976) presents the following diachronic changes in Spanish as clear examples of the avoidance of bad syllable contact:

(1)	venira	>	venra	>	vendra	'(it) will come'
	ponira	>	ponra	>	pondra	'(it) will put'
	salira	>	salra	>	saldra	'(it) will leave'

The phenomenon of syncope gave rise to sequences of nasal plus liquid or liquid plus liquid, sequences which violate her syllable contact law. Spanish dialects eliminate this violation in various ways. The one illustrated above is the insertion of an intrusive stop. However, other changes are conceivable, and do, indeed, occur in other dialects, as is shown by forms like verna, porna which have undergone a rule of metathesis, and verra, porra which have undergone a gemination rule. The Spanish example shows that languages have several options to eliminate 'bad syllable contact' situations, and which option is chosen varies from language to language, and cannot be predicted.

We will suggest that the resolution of vocalic hiatus is, at least at the current stage of understanding, another manifestation of the same phenomenon: the elimination of bad syllable contact. This implies that the syllable and the principles of syllabification will play a major role in the description of vowel coalescence throughtout this thesis.

Several mechanisms are employed to resolve a vocalic hiatus: insertion, deletion and fusion, and once again it seems to be currently impossible to predict which option is preferred. We will briefly discuss these mechanisms by giving some examples.

A very common strategy is the insertion of a (homorganic) glide or glottal stop between the vowels in hiatus. Less common is the insertion of a full consonant in this environment. The following examples from Dutch, taken from Trommelen and Zonneveld (1979) illustrate the insertion solution:

(2) a: drie [i] - drie[y]en 'three' b: barbecue [u] - barbecue[w]en id.

(2) a: drie	[i] - drie[y]en	'three'	b: barbecue	[u] - barbecue[w]en	id.
bleu	[ö] - bleu[y]e	'shy'	echo	[o] - echo[w]en	id.
cru	[ü] - cru[y]e	'crude'	judo	[o] - judo[w]en	id.
ree	[e] - ree[y]en	'hind'	interview[u]	- intervie[w]en	id.

(3) de koning van Spanje-[n]-is dood 'the king of Spain is dead'
hij geeft me-[n]-een boek 'he gives me a book'
Mieke-[n]-is de dame-[n]-in het zwart 'Mieke is the lady in black'

The second possible solution to the hiatus problem is the deletion of one of the vowels. The following examples from Urhobo, an Edo language spoken in Nigeria (cf. Elugbe 1972) are illustrations:

(4) ɔ̀ dí'bí (←ɔ dɛ́ ìbí) 'he bought seeds'
ɔ̀ détòn (←ɔ dɛ́ etòn) 'he bought hair'
ɔ̀ dáŋmá (←ɔ dɛ́ aŋmá) 'he bought cloths'
ò fúré (←o fó úré) 'he jumped a tree'

The third and most intriguing option is the fusion or merger of the vowels in hiatus into a monophthong or diphthong. A clear example of this type is vowel coalescence in Old Portuguese (henceforth OP), discussed in Naro (1971) and De Haas (1987a). In this language, two processes are in complementary distribution. First, unstressed nonlow vowels raise in the immediate environment of another vowel. The resulting high vowel combines with the remaining vowel to produce a diphthong. All other sequences of nonhigh vowels undergo a vowel contraction or vowel coalescence rule (we will use both notions interchangeably). The input vowels are merged into a single long vowel, which is in a way an articulatory compromise between the two input vowels. Both changes are illustrated in (5):

(5)

a: mál-o	→ mau	'bad'(1.decl.sg.)	b: até agora	→ atɛ̄gora	'until now'
vol-ár	→ vuar	'to fly'	deza óyta	→ dezɔ̄yta	'seventeen'
nɛ́vol-a	→ nɛvua	'fog'	sól-a	→ sɔ̄	'only'(fem.sg.)
kwáles	→ kwais	'which'(3.decl.pl.)	rad-ér	→ rɛ̄r	'to scrape'

In this thesis, we will be concerned with the latter type of hiatus resolution. Linguistic theory in its present state seeks to characterize linguistic form in all its diversity, with clear emphasis on the exposition of the common characteristics of human languages. As a consequence, the detailed description of individual languages will not receive our prime attention. We will focus on the discovery and formulation of the general and sometimes universal principles governing these processes. The formulation of such principles makes it possible to explain similar processes in a large number of languages. We will, to this end, develop a formal theory of vowel coalescence in the remainder of this chapter.

This hypothesis will be put to the test on the basis of a detailed analysis of Ancient Greek, and a number of relatively shallower analyses of other languages.

It will be hypothesized that vowel coalescence should be regarded as the fusion of the segmental make-up of vocoids, if and only if the sounds involved are nondistinct. Furthermore, we will suggest that coalescence is restricted to tautosyllabic vocalic sounds. As a consequence, a rule of resyllabification must apply prior to coalescence in situations where the input vowels are heterosyllabic in underlying representation (cf. the OP forms in (5) above). Hence, two vocoids will merge into a monophthong if they are nondistinct, and into a diphthong if they are distinct.

This chapter will proceed along the following lines of exposition. We will first discuss a number of previous linear and nonlinear analyses of vowel coalescence, and we will point out some general shortcomings of these approaches. Next, we will outline an alternative approach that is not liable to the same criticism.

2.1 Previous analyses

Chomsky and Halle (1968) already observe that vowel coalescence (VC) cannot be described properly with the rule format given in (6).

(6) $A \rightarrow B \;/\; C \;\text{—}\; D$

They therefore argue that transformational power is needed in the phonological component to handle processes such as vowel coalescence and metathesis. The general format of contraction which can be deduced from their discussion of Kasem is the one represented in (7):

(7) $$\underset{1}{\begin{bmatrix} aF \\ cG \end{bmatrix}} \; \underset{2}{\begin{bmatrix} bF \\ dG \end{bmatrix}} \rightarrow \underset{1}{\begin{bmatrix} aF \\ dG \end{bmatrix}} \; \emptyset$$

In alternative linear proposals, VC is conceived as a (special) type of assimilation. It is special in that assimilation rules are usually directional, whereas VC is inherently bidirectional. Moreover, assimilation rules change one feature or a class of features, whereas VC changes a set of features which do not necessarily constitute a single unit. This is why in these alternative analyses the mirror-image device and the parentheses device find frequent application. Diagram (8) shows the essentials of the assimilation concept:

(8) a: Vowel Assimilation

$[+\text{syll}] \rightarrow [\alpha F] \;/\; \text{—}\; [\alpha F]$

b: Vowel Contraction

$$[+\text{syll}] \rightarrow \begin{Bmatrix} [aF] \;\%\; [aF] \\ [bG] \;\%\; [bG] \end{Bmatrix}$$

One of the major characteristics of vowel contraction is that the quality of the output is a derivative of the quality of the input vowels, that is, the output shares properties with both input vowels. Furthermore, the quantity of the output is identical to the sum of the input vowels, unless this situation is overruled by language-specific or universal processes. These properties can be observed in OP, but a more complete picture can be obtained from Korean (cf. Sohn 1987). In (9) below an incomplete diagram of the possible vowel mergers in this language is given as an illustration:[1]

(9)

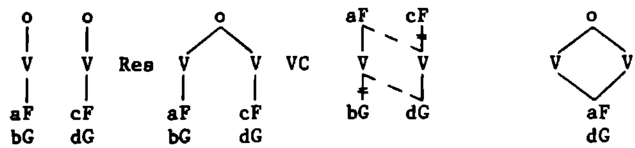
	i	e	a	o	u
i	i	e	æ	ö	ü
e	e	e	æ	o	ö
a	æ	æ	a	(ɔ)	(ɔ)
o	ö	ö	(ɔ)	o	o
u	ü	ö	(ɔ)	o	u

The expression of the major characteristics of vowel coalescence noticed above is problematic in both linear approaches, since no natural limit is imposed upon the potential outputs of coalescence, neither with respect to quantity nor, and even more crucially so, with respect to quality. In other words, the quality as well as the quantity of the output are more or less derived by accident. In chapter 1, we have made clear that the assumption regarding assimilation as feature-changing allows for changes that are empirically unattested, viz. changes where the target acquires a feature value which is not present in the trigger. The same criticism can be brought forward with respect to both linear accounts of VC. Nothing in the formalism prevents changes that are unattested cross-linguistically. Furthermore, suprasegmental properties such as length are represented by distinctive features.[2] To account for VC in Korean and OP the feature [+long] must be mentioned in the structural change of the rule. However, nothing in the formalism forces us to do so. Hence, linear phonology does not seem to be a suitable candidate to deal with vowel coalescence. The observation that VC affects the segmental make-up of the vowels in hiatus, without affecting the suprasegmental properties of the sequence as a whole (duration, stress, tone) strongly suggests a nonlinear approach to the process in question, since in nonlinear phonology the segmental and suprasegmental properties are arrayed on independent layers or planes. We therefore expect processes that accomplish changes in one plane without modifying the others. The autosegmental literature shows (cf. Goldsmith 1976, Clements and Keyser 1983 and most of the studies collected in Wetzels and Sezer 1986, among others) that this prediction is correct. The phenomenon of vowel coalescence is yet another example supporting the existence of this basic subdivision within the linguistic structure of sounds.

Let us turn to the existing nonlinear analyses of VC, in which essentially two approaches can be distinguished. Wetzels (1986) and De Haas (1987a) argue that the notion of resyllabification is of crucial importance. More specifically, vowel contraction is regarded as the spreading of dominant feature values within the domain of the (derived) syllable. An alternative line of argument is suggested by Schein and Steriade (1986). These authors characterize contraction as a phenomenon whereby the place features of the right-hand vowel spread onto the left-hand vowel with concomitant delinking from their original position. As a result, the root node of V_2 remains empty, and will be pruned, unless the language has an independent rule of compensatory lengthening, which ensures that the resulting empty slot will be linked to the matrix derived by vowel contraction. We will consider each of these approaches in turn.

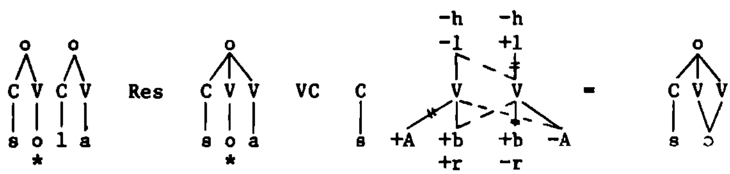
Wetzels and De Haas discuss vowel coalescence processes in Ancient Greek, and OP and Kasem, respectively. In both analyses, a theory of full specification is assumed, and as a consequence, it has to be stipulated which feature values are the dominant, that is, which are the spreading values. In outline, the effects of vowel contraction can be represented as in (10):

(10)



We will illustrate this diagram with a concrete example from OP (/sól-a/ → [sɔ̄] 'only'(fem.sg.):

(11)



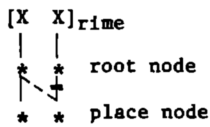
In OP two vowels can become adjacent by a general process that deletes voiced consonants in intervocalic position. This situation is resolved by resyllabification and subsequent contraction. The latter process entails the nondirectional spreading of the dominant feature values [-low], [+round], [-back] and [-ATR].

The main problems for this analysis are twofold. First of all, it must be stipulated - time after time - which feature values are dominant. Aware of this problem, we suggested in our (1987a) paper to attribute most of the dominant values to UG, since if one of the input vowels is [-high], [-low], [-ATR] or [+round], language after language preserve these values. A second problem is that VC in OP, and in many other languages, apparently involves the independent spreading of several feature nodes in different directions at the same time. However, the theory of feature geometry proposed in chapter 1, combined with the independent hypothesis of assimilation as spreading, entails the claim that natural assimilation processes involve the spreading of at most a single node in the feature tree. At first sight, it seems that the contraction data force us to relax this empirical claim. Alternatively, we can hold on to the strongest version of the theory, and take the spreading of more than one node as an indication of the relatively marked status of VC with respect to the other options (insertion or deletion), or as an indication of the telescoping of historically distinct processes, also resulting in a synchronically 'marked' situation.

It will become apparent, however, that coalescence processes are neither marked nor necessarily telescopings of originally independent processes. Anticipating the presentation of this evidence, we will assume that analyses which include derivations such as (9) or (10) are incorrect.

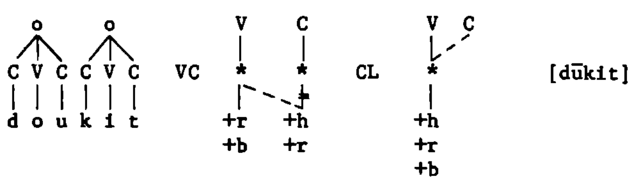
Schein and Steriade (1986) circumvent these objections by assuming that VC is a directional spreading rule whereby the set of place features spread from one timing slot to the other. Schematically, their formal characterization of vowel contraction takes the form in (12):

(12)

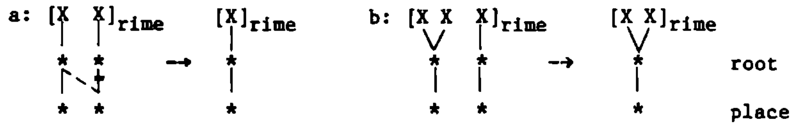


In their view, VC involves the merger of the feature specifications contained within the input sequence. Given their assumption that default values are supplied by later redundancy rules, they do not need to stipulate the dominant feature values. Their analysis implies that lexically present values dominate by definition. They state, furthermore, that contraction should be conceived as an "articulatory compromise". If the place features of a sequence V_1V_2 become exclusively linked to the root node of the left-hand vowel, they predict that the output of contraction is a short vowel in the unmarked case. For contraction in Classical Latin - the language Schein and Steriade discuss - this prediction is incorrect. However, they claim that the lengthening effect does not belong to VC proper, but is the result of another independent process of Latin, namely Compensatory Lengthening (CL). In (13) below, we give the effects of their analysis for the Latin form dūkit (<dowkit) 'leads':

(13)

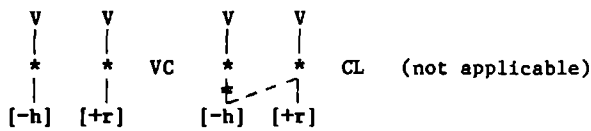


The supposed interaction between vowel coalescence and compensatory lengthening is of course an empirical claim and can be falsified only on the basis of empirical evidence. Recall that we have claimed just the opposite, that is, the output of vowel contraction is a long vowel, unless a language-specific shortening rule obscures this effect. Empirical evidence against Schein and Steriade's view is not difficult to find. For example, Old Portuguese has no independently motivated rule of compensatory lengthening, while it has a process of vowel coalescence. Schein and Steriade (1986) therefore predict that the vowel which result from VC will be short. However, in OP a long vowel arises by means of this process, a situation which is in perfect accord with our expectations. Furthermore, in languages which do not have a rule of compensatory lengthening, they incorrectly predict that vowel coalescence results in a long vowel if the first input vowel is long and in a short vowel if the first input vowel is short, as schematically depicted in (14):

(14)


McCarthy and Prince (1986:52) state that this type of length preservation is abnormal cross-linguistically, and that vowel coalescence typically yields vowels that are long or short uniformly in any language.

There is a third important problem for the analysis by Schein and Steriade. They must stipulate the direction of spreading (right to left). A priori the opposite direction of spreading (left to right) is equally plausible. However, in that case we expect languages like (15) which have a rule of VC (left to right spreading) and a rule of CL (left to right spreading) in which the output of VC remains short:

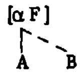
(15)


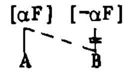
Situations like this are not documented in the literature, as far as we know. Consequently, Schein and Steriade must invoke additional mechanisms to account for the absence of languages like (15). For example, they might assume that VC rules universally spread from right to left. However, in that case they express the observation that the direction of spreading is really irrelevant in an indirect way. It will turn out that this observation can be expressed directly in our alternative proposal. We will take the existence of languages like Old Portuguese, where the length of the output of VC cannot be derived from an independent rule of compensatory lengthening, and the absence of languages like (14) and (15), as a strong indication that Schein and Steriade's (1986) proposal is seriously flawed.

In our analysis, the output of VC is a long vowel in languages both with and without a rule of CL. Nevertheless, languages are attested in which the output is a short vowel (e.g. Kasem, Korean, Old French). The discussion of these languages will reveal that this shortening is the result of independently motivated shortening rules. Thus, in the present treatment, VC entails vowel-length preservation rather than the loss of vowel length, quite the reverse of the relation assumed by Schein and Steriade. If a language has a rule of VC and a vowel shortening rule, the output of VC will be short. On the other hand, if a language lacks a vowel shortening rule, the output of VC will be long. Below, we will outline our alternative formalization of contraction.

2.2 Vowel Contraction as feature node coalescence

Halle and Vergnaud (1980), Steriade (1982) and subsequent authors in autosegmental phonology suppose that assimilation is best represented by feature-spreading rules like those in (16):

(16) a:


b:


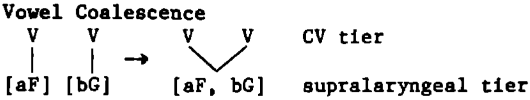
The autosegment [αF] spreads from the trigger A onto the target B followed, in the unmarked case, by delinking of [−αF] if B is specified for [F].

All previous analyses of VC regard this process as an assimilation in which features spread from a trigger onto a target in particular environments. Our formal characterization of contraction will be different, since the properties of VC do not tally with the properties of true assimilation. As observed, the processes under discussion differ at least in two respects.

(a) Assimilation rules are directional in the sense that we can characterize one segment as the trigger and the other as the target. Coalescence, on the other hand, is inherently bidirectional, and the segments involved are trigger as well as target.

(b) Assimilation rules involve the spreading of a single node in the feature geometry, whereas coalescence includes changes in more than one feature node.

We can account for these general properties of VC by assuming that this process must be stated in the way its name implies, viz. as the merger, or fusion, of the phonetic content of both input vowels.* As a result, our analysis will reflect the observation that the output of coalescence is an articulatory compromise. In autosegmental terms, we state VC as follows:

(17) Vowel Coalescence


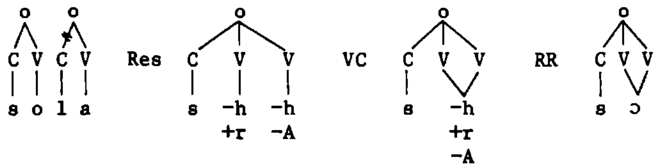
The change accomplished by (17) is that two adjacent supralaryngeal nodes are merged into a single node shared by two skeleton slots. The merger of single class nodes conforms to the theory of feature geometry. Furthermore, the inherent bidirectionality, which can be observed from the preservation of the segmental properties of both input vowels, is accomplished by the introduction of a fusion mechanism.

An important aspect of the analysis proposed by Schein and Steriade (1986), as well as our analysis, is that the notion of structure preservation must be refined. In both analyses the distinctive properties of both input vowels are preserved irrespective of the existence of the resulting vowel in underlying representation. For example, if the features [+round] and [−back] are present in underlying representation, while the opposite values are unspecified, both analyses predict that o+e coalescence will result in the front rounded vowel [ö], even in cases where the output vowel is not present underlyingly. The Korean examples discussed above show that this prediction is presumably correct. Hence, from a general perspective it seems that two kinds of structure preservation must be distinguished. The first type is applicable to the phoneme level and entails that the underlying sound inventory cannot be enlarged by lexical phonological rules. The second type is applicable to the distinctive-feature level, and here it entails that the lexically specified feature values must be preserved. These two interpretations of structure preservation are sometimes contradictory as is shown by the Korean facts in (9). The vowels /ŏ, ü/ do not belong to the underlying vowel system, but arise by vowel coalescence. Thus, this process is not structure-preserving at the level of the underlying phonemes, but only at the level of the distinctive features. This observation indicates that the tendency toward feature preservation is stronger than that toward underlying phoneme preservation.

Structure preservation at the phoneme level, on the other hand, seems to be rather problematic. Many examples are reported in the literature that violate this principle (cf. Halle and Mohanan (1985) for English, Mohanan and Mohanan (1984) for Malayalam, Christdas (1987) for Tamil, Clements and Keyser (1983) for Klamath...etc.). If structure preservation at the level of the distinctive features is more powerful, it is worth investigating whether violations at the phoneme level can occur if and only if they are manifestations of structure preservation at the distinctive-feature level. We will return to this interesting hypothesis in more detail below (section 5.2.3).

The characterization of VC argued for here is made possible by the introduction of UT, because if we assumed fully-specified feature matrices, the general format in (17) would not do. It would be necessary to add additional stipulations to the effect that matrices are scanned for dominant feature values. If such a value is present, it will be preserved; if not, the recessive value is preserved. This concept is more complex and has less explanatory value. It is more complex, because matrices must be scanned, and it has less explanatory value, because stipulations regarding dominance must be added. Both stipulations are superfluous in our approach, because we do not need a scanner and we do not have to stipulate which feature values are dominant. The dominant values are the lexically specified values. Their presence is determined by UG or by language-specific evidence which motivates deviations from the universal pattern.

As an illustration of the effects of the general format of VC, we present the derivation of the OP form [sɔ̃] 'only'(fem.sg.). For this language, we will assume the lexical values [-high], [-back], [+round] and [-ATR] to distinguish the underlying vowels /i, e, ɛ, a, ɔ, o, u/. The first three are determined by UG, and the value for [ATR] is probably language-specific. The consequences of these assumptions with respect to VC are shown in (18):

(18) 

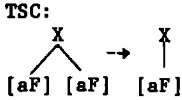
In section 1.1, we have adopted the general format of autosegmental phonology in which P-rules take the form of spreading and/or delinking rules. The format in (15) reveals that neither of these mechanisms is employed. Hence, we apparently introduce a new mechanism into phonological theory. This is true, but it will turn out that the fusion mechanism has already been well documented in the literature. Remember first of all our discussion of Steriade's (1982) Shared Features Convention in section 1.1.3.4. According to this convention, when two slots share at least one feature by means of the application of a P-rule, then all remaining identical features undergo merger.

Similar fusion principles proposed in the literature are: (i) the Obligatory Contour Principle[3] (OCP) or Tier Conflation (cf. Leben 1973, Goldsmith 1976, McCarthy 1986, Yip 1988), (ii) the Twin-Sister Convention (cf. Clements and Keyser 1983, Clements 1986b), and (iii) the Nuclear Fusion Principle (cf. Wetzels 1986, De Haas 1986b). In (19) below, we present the formulations of these general conventions:

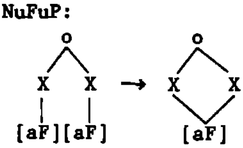
(19) a: OCP/Tier Conflation:

$[\ldots[\alpha F]\ [\alpha F]\ldots] \rightarrow [\ldots[\alpha F]\ldots]$

b: TSC:



c: NuFuP:



These general fusion conventions are empirically well motivated, and we can draw the conclusion that the characterization of VC as a fusion process without making use of spreading and/or delinking does not lead to the introduction of a new and possibly powerful tool into phonological theory.

A second aspect of our characterization of vowel coalescence is the claim that these processes are confined to the domain of the syllable. This implies that heterosyllabic vowels first have to undergo a rule of resyllabification prior to the application of vowel coalescence. The specific purpose of the remainder of this section is to provide sufficient motivation in favor of this claim.

Schein and Steriade (1986) discuss the monophthongization of the Old Latin diphthongs /ey, oy, ow/. This sound change fails to affect diphthongs containing the first half of a geminate. Moreover, heterosyllabic /ey, oy, ow/ clusters also resist monophthongization. The examples in (20) illustrate the conditions on this phenomenon:

(20) a:	dey.wos > dīwos	'god'	b:	o.wis	'sheep'
	oy.tile > ūtile	'useful'		pey.yor	'worse'
	dow.kit > dūkit	'leads'		Troy.ya	'Troy'

The absence of contraction in (20b) can be straightforwardly accounted for by confining VC to tautosyllabic vocoids. In that case, a form like owis does not fulfill the requirements for contraction, whereas a form like peyyor fails to undergo contraction because of the Linking Constraint, which blocks contraction. In case of geminate glides, the association lines mentioned in the formulation of contraction cannot be interpreted as exhaustive.

Contraction in Korean is of particular interest. In this language, the merger of vocoids is optional. The forms in (21) are characteristic of this process:

(21) a:	na.ɨmyən	~	nāmyən	'to deliver (a baby)'	(*na.amyən)
	tu.ə	~	tō	'to leave'	(*to.o)
	pe.ə	~	pē	'to cut'	(*pe.e)
	nə.eke	~	nēke	'to you'	(*ne.eke)
	na.eke	~	nǣke	'to me'	(*næ.æke)
	ta.a	~	tā	'to arrive'	
b:	kwe.mul	~	kȫmul	'monster'	
	wisəŋ	~	üsəŋ	'hypocracy'	
	p'yam	~	p'æm	'cheek'	
	p'yocok	~	p'öcok	'sharp'	
	toyaci	~	twæci	'pig' (*tö.aci)	

These data can be derived by one general VC rule, although we can observe a length distinction between the forms in (a) versus (b, c). For the present discussion, this contrast is irrelevant. We will return to this issue in chapter 5, where we will show that the short vowels result from an independent syllable constraint.

We can observe that VC in Korean exhibits essentially the same properties as its counterpart in Latin. Contraction seems to be restricted to tautosyllabic vocoids. If we took the opposite position, that is, if we assumed that VC applies irrespective of syllabification, we would not be able to account for the ill-formed items in (21) without additional stipulations. For example, the forms in (21c) could be explained by stipulating that coalescence applies from right to left. The forms in (21a) follow if we posit a later rule of resyllabification which applies exclusively to heterosyllabic vowels associated to the same melody. Thus, the simplest grammar is the one in which resyllabification feeds vowel coalescence, unless it can be shown that one of the additional assumptions is cost-free. Levin (1985) argues that it is universally true that long vowels, i.e. one melody associated to two V-slots, are tautosyllabic. Under this assumption, the ordering of vowel coalescence before resyllabification would be cost-free, and we would not have to posit a language-specific resyllabification rule, since resyllabification would be dictated by Universal Grammar. Below, we will argue that the resyllabification of heterosyllabic vowels linked to one melodic root cannot be derived from a universal principle. To see why this is the case, we must take into consideration the major differences between vowel coalescence and vowel harmony.

Vowel harmony can be observed in numerous human languages. In broad outline, it can be characterized as a phenomenon which makes vowels within a particular domain agree with respect to one or more harmonizing features. Vowel harmony is a long-distance process and intermediate consonants are usually ignored. Vowel coalescence, on the other hand, is strictly local, and confined to adjacent vowels. Furthermore, vowel harmony rules do not induce resyllabification of vowels, while vowel coalescence always involves resyllabification. We will show that the claim that resyllabification feeds contraction enables us to distinguish vowel harmony from vowel coalescence, while the distinction is lost under the opposite assumption. Let us therefore take a look at a well-known vowel harmony system, viz. [ATR] harmony in the West African language Akan (cf. Clements 1981). The vowels of Akan fall into two harmonic sets, the [+ATR] set /i, e, o, u/, and the [-ATR] set /I, E, a, O, U/. Additionally, the low vowel /a/ is non-alternating or opaque, and may occur in roots containing vowels of either the [+ATR] and [-ATR] set. A representative sample of the facts of Akan is presented in (22):

(22) a:	e-bu-o	'nest'	b:	E-bU-O	'stone'
	o-kusi-e	'rat'		O-kOdI-E	'eagle'
	o-fiti-i	'he pierced (it)'		O-cIrE-I	'he showed (it)'
c:	O-kasa-I	'he spoke'			
	O-kari-i	'he weighed (it)'			
	o-nanI-I	'he woke up'			

These forms show that [ATR] harmony takes place irrespective of intermediate consonants. Of interest are the forms where the root-final vowel and the suffix vowel become identical. The application of the harmony rule will activate the universal Shared Features Convention, and the result will be a heterosyllabic vowel sequence linked to one melodic root. Given Levin's (1985) claim that such sequences automatically undergo resyllabification, it is wrongly predicted that a tautosyllabic long vowel arises. Hence, vowel sequences which, more or less by accident, become identical by means of vowel harmony do not undergo resyllabification. The observation that a melodic root linked to a heterosyllabic VV-sequence does not undergo automatic resyllabification entails that, in the case of Korean vowel coalescence, obligatory resyllabification cannot be derived from Universal Grammar, and points to the conclusion that the simplest grammar of Korean is the one in which resyllabification triggers vowel coalescence. Furthermore, the claim that resyllabification feeds vowel coalescence enables us to account for one of the fundamental differences between vowel harmony and vowel coalescence. The former phenomenon accounts for nonlocal feature-cooccurrence restrictions, while the latter accounts for local vowel cooccurrence restrictions. In our proposal this difference is due to the notion of resyllabification. Vowel coalescence is a hiatus avoidance phenomenon triggered by resyllabification, whereas vowel harmony and resyllabification are entirely irrelevant to one another's operation.

A fourth piece of evidence comes from Old Portuguese. As already noticed above, two processes apply in complementary environments, viz. vowel raising and vowel coalescence. In De Haas (1987a), we argued that both rules are activated by resyllabification. Basically, two arguments support that claim. Unstressed nonlow vowels are raised if they are immediately adjacent to a vowel (cf. 5a above). However, a large set of forms exists which resist VR. If two vowels are identical they merge into a long monophthong, as shown in (23a). In addition, under specific morphological conditions, the vocalic hiatus is left unresolved, that is, neither resyllabification nor vowel coalescence takes place, as illustrated in (23b):

(23)	a:	vedér → vẽr	'to see'	b:	krédem → kre.ẽy	'they believe'
		féde → fẽ	'faith'		tɛ́nem → tɛ̃.ẽy	'they have'
		avólo → avõ	'grandfather'		koróno → korõ.o	'I wash'
		sólo → sɔ̃	'only		sɔ́no → sɔ̃.o	'I sound'
	c:	aréna → are[y]a	'sand'			
		bóna → bo[y]a	'sound'			
		téla → te[y]a	'web'			

These data supportthe hypothesis. After resyllabification, the two identical vowels are input to the universal NuFuP (cf. 19c), which creates shared matrices and destroys the configuration to which VR would be applicable. We cannot invoke the OCP to explain these facts, since then we would incorrectly derive *krẽ̄y 'they believe' and *korȭ 'I wash'. The forms in (23b, c) must be marked as lexical exceptions in any analysis. If it is assumed that vowel coalescence precedes resyllabification they must even be marked twice, once for vowel coalescence and once for resyllabification. Under the ordering assumed, we have to mark them as [-resyllabification] only.

Furthermore, on the assumption that resyllabification feeds vowel coalescence, we account for two systematic gaps in the data. Forms in which VR or VC take place without resyllabification are unattested. These gaps are principled ones, if we adhere to our empirical claim, and predict that languages in which VR or VC result in, respectively, heterosyllabic diphthongs or monophthongs do not occur.

In Ancient Greek high and nonhigh vowels behave differently in hiatus. The forms in (24) show that two nonhigh vowels undergo resyllabification and subsequent vowel coalescence. If, on the other hand, the rightmost input vowel is a high vowel, the hiatus is resolved by resyllabification into a diphthong:

(22)	a:	gene+a → génɛ̃	'race'(nom.acc.pl.)
		gene+i → géney	id. (dat.sg.)

b: gera+a → gérā 'prize'
gera+i → géray id.
c: aydo+a → aydɔ̂ 'shame'(acc.sg.)
aydo+i → aydôy id.

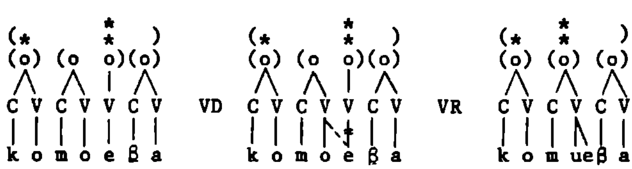
The examples above show that resyllabification applies independently of vowel coalescence. If we assume that vowel coalescence is preceded by resyllabification, we are able to treat high and nonhigh vowels on a par: both sets of vowels undergo resyllabification. In the case of a right-hand high vowel the result is a diphthong, and in the case of a right-hand nonhigh vowel the result is a long monophthong. Conversely, if vowel coalescence took place irrespective of resyllabification, we would have to posit one resyllabification rule to change the output of coalescence into a tautosyllabic long vowel. In addition, a second resyllabification rule would be needed applying exclusively to sequences where the rightmost vowel is [+high]. This analysis, however, obscures the fact that vowel coalescence and diphthongization serve one and the same purpose: the resolution of vocalic hiatus.

Clements and Keyser (1983) discuss alegretto sandhi in Chicano Spanish which highly resembles VR in Old Portuguese. Some typical examples are given in (25):

(25) téngo hípo	→	tèngu̯ípo	'I have the hiccups'
cómo Éva	→	kòmu̯éβa	'like Eva'
comí uvítas	→	komi̯uβítas	'I ate grapes'
cortó uvítas	→	kortŭβítas	'he cut grapes'

("˘" indicates a very short vowel)

To account for these facts, Clements and Keyser posit a rule of Vowel Degemination (VD), which links the rightmost vowel to the skeleton slot of its left neighbor with concomitant deletion of its original slot. This rule feeds Mid-Vowel Raising, which assigns the feature [+high] to all vowel slots which are doubly linked. In (26), we give the course of the derivation for [kòmu̯éβa]:

(26)


So once again, we observe that two heterosyllabic vowels must become tautosyllabic first (by VD), before Mid-Vowel Raising can apply. These rules must be ordered as indicated, because otherwise it would be impossible to explain why underlying /o+o/ and /e+e/ sequences fail to undergo raising. This failure is expected under Clements and Keyser's analysis, since sequences of identical vowels are input to the Twin-Sister Convention after the rule of degemination.

The discussions of Latin, Korean, Old Portuguese, Ancient Greek and Chicano Spanish reveal that the claim concerning the feeding order between resyllabification and vowel coalescence is well supported cross-linguistically. We have shown that the simplest grammar of these languages is the one in which vowel coalescence is confined to the domain of the syllable. We will take this evidence as sufficient motivation for the strong empirical claim that this feeding order is determined by UG. Furthermore, we have discussed vowel harmony in Akan, demonstrating that this process does not involve resyllabification, even in cases where two identical vowels arise. For example, in the form [o-fiti-i] 'he pierced (it)' the two high vowels in hiatus do not merge into *[o-fitī] by resyllabification, whereas two identical vowels arising from vowel coalescence always undergo resyllabification. We take this important difference between vowel coalescence and vowel harmony as a strong indication that the former is triggered by resyllabification, while the latter applies completely independently of this process. If resyllabification of two V-slots associated to one melodic root is an automatic consequence of a universal principle, the difference between vowel harmony and vowel coalescence is lost.

One important issue will be addressed here in order to wind up this chapter. In our introductory remarks we noted that the fusion of a vowel sequence results either in a monophthong or in a diphthong. The formalization of vowel contraction in (17) enables us to derive only monophthongs. The important question therefore is: How can diphthongs arise in our analysis? Related to this issue is the bifurcation among the languages having a rule of VC. In languages like Ancient Greek and OP only nonhigh vowels undergo contraction into a long vowel. A sequence of a nonhigh and a high vowel results in a diphthong. In Classical Sanskrit, Korean, Rotuman..etc. no such height restriction is imposed on contraction, although in Classical Sanskrit a condition is imposed on the length of the left-hand vowel. We can therefore distinguish three major types of languages, viz. those in (27a) in which contraction produces monophthongs and diphthongs, those in (27b) in which contraction yields only monophthongs, and those in (27c) in which monophthongs arise if the left input vowel is short and diphthongs if the left input vowel is long:

(27) a: Type I	b: Type II	c: Type III
e+e → ē	e+e → ē	a+i → ɛ̄
e+i → ey	e+i → ē	ā+i → āy
e+o → ō	e+o → ō	a+u → ɔ̄
e+u → ew	e+u → ō	ā+u → āw
a+i → ay	a+i → ɛ̄	e+o → ō
a+u → aw	a+u → ɔ̄	a+a → ā

The theory of underspecification outlined in section 1.2 in combination with the principles of CV Phonology provides an adequate solution to this provocative problem. We would like to emphasize once more that UT is crucial to the formal characterization of VC given above. In a theory of full specification all kinds of additional stipulations would be necessary. We will suggest here that the existence of the distinction between type-I, II, and III is determined by two parameters: distinctness and position in the syllable. If high and nonhigh vowels are distinct, vowel coalescence cannot merge a sequence of a nonhigh and high vowel, the result of resyllabification will be a diphthong. If, on the other hand, high and nonhigh vowels are nondistinct, that is, one is specified for [high], while the other is still unspecified for height, two situations can arise as a result of the second parameter. If the rule of vowel coalescence is confined to the domain of the syllable, any vocoid can undergo merger into a monophthong. However, if VC is confined to the nucleus, a sequence of a nonhigh and a high vowel will merge, if and only if both vowels are within the domain of the nucleus. Pre-nuclear and post-nuclear high vowels do not participate in merger. In chapter 5, we will return to this issue and it will be shown that the three types of VC languages expected under our theory are indeed attested.

The type-II and -III languages lack language-specific processes that (i) are ordered before VC and (ii) crucially refer to the redundant value for [high]. As a consequence, the RROC will be left unactivated, and at the point in the derivation where VC is applicable only the lexical value for [high] is present. However, in the type-I languages the situation is clearly different. Ancient Greek has two processes ordered before VC: Stem Vowel Lowering and Metathesis of Quantity, and both refer to the underlyingly absent value for [high]. In OP, vowel raising precedes vowel coalescence and assigns the redundant value [+high] to the unstressed nonlow vowels. Thus, in these languages both the lexical and the redundant value for [high] occur at the point where VC applies. For contraction to apply to a sequence of a nonhigh and a high vowel, we would have to stipulate the dominant value, and a scanning mechanism tracing its exact location. Notice, however, that we would nullify all advantages of the theory of underspecification with respect to the formal characterization of vowel contraction if we were to allow mergers of the segmental make-up in situations where at least one feature has opposite values. To solve this problem, we claim that the merger of nodes in the feature geometry is in fact severely restricted: fusion of feature nodes is allowed, if and only if the content of these nodes is nondistinct.

In conclusion, we have argued that previous linear and nonlinear analyses of VC fail to account for the principal characteristics of this phenomenon. We have established that vowel contraction is a hiatus resolution process, and that all instances of the rule share the following fundamental properties:

(28) a: the quality of the output is a derivative or articulatory compromise of the quality of the input vowels.

b: the quantity of the output is the sum of that of the input vowels, that is, the skeleton and all higher-level prosodic units are unaffected by VC.

c: all lexically specified feature values are preserved, irrespective of whether the output vowel is underlyingly present.

d: merger of feature nodes is confined to the domain of the syllable or the syllable nucleus.

e: the trigger and target vowels are indistinguishable, and VC is therefore inherently bidirectional.

Together, these five phonological characteristics define what we will call vowel coalescence or vowel contraction, and enable us to distinguish VC from other processes affecting the segmental make-up of vocalic sounds such as metaphony and harmony. For example, if a process is not confined to tautosyllabic vocoids, it cannot be a VC rule because of characteristic (28d). Similarly, if a V_1+V_2 sequence is changed into a heterosyllabic V_1V_1 or into a V_2V_2 sequence, as in the West African language Vata spoken in the Ivory Coast (cf. Kaye 1982), these changes cannot be the result of VC, since the characteristics in (28c) and (28d) are violated. The ensuing chapters will be devoted to an elaboration of the hypotheses proposed here. In the next two chapters, we providea detailed analysis of Ancient Greek, and in chapter 5 we will compare VC in Ancient Greek with similar processes in other, unrelated languages.

Footnotes

1: The Korean vowels /ə, æ, ɨ/ are left out of consideration. Their behavior coforms to the general pattern of diagram (9). The vowel [ɔ] is parenthesized, as it does not occur in Korean.

2: In linear phonology there are two ways to represent long segments: (i) they can be represented as a single segment specified [+long], or (ii) they can be represented as a cluster of two identical short segments. It will be clear that the criticism brought forward is only applicable to the former manner of representation. Pyle (1971) shows for languages such as West Greenlandic Eskimo and Lithuanian that both ways to represent long segments are necessary in order to account for the fact that long segments behaves as clusters for some phonological rules, and as single segments for others. A similar situation occurs in Old Portuguese. The observation that vowel contraction yields long vowels seems to indicate the correctness of the cluster representation. However, Old Portuguese has a rule of mid vowel raising that raises short as well as long vowels before a nasal consonant (e.g. /tɛmpos/ → [tempos] 'time', /pɔ̄mbo/ → [pōmbo] 'pigeon'. In order to derive the correct surface forms, long vowels must be represented as single [+long] segments. This brief discussion reveals that linear phonology fails to provide a uniform way of representing long segments. In nonlinear phonology, on the other hand, long segments are single melodic roots associated to two skeleton slots on the CV tier, and transformations of the type aa → ā, or vice versa, are superfluous.

3: McCarthy (1986) argues that the OCP should not be considered a fusion principle. He claims that the OCP is a well-formedness convention which prevents OCP violations from coming into existence. However, Odden (1986b) and De Haas (1987a) show that this version of the OCP is untenable. In Old Portuguese, for instance, the /l/ in /palašo/ is deleted although it results in an OCP violation. Under McCarthy's interpretation, deletion rules like the one in OP should be blocked if its output does not meet the OCP. Over and above this, however, he proposes the principle of Tier Conflation which merges two identical (auto-)segments across a morpheme boundary to prevent OCP violations, as illustrated in (i) below:

```
(i)       t
          |
..C + C..  Tier Conflation  ..C C..
  |                           \/
  t                           t
```

* After the completion of this thesis we found out that similar ideas concerning vowel coalescence as merger are independently proposed by Schane (1987) ("The Resolution of Hiatus", in A. Bosch et al. (eds.), Papers from the Parasession on Autosegmental and metrical Phonology, Chicago: Chicago Linguistics Club, 279-290). Schane's ideas are formalized within the framework of Particle Phonology. As far as we can see, he does not solve the problems we have raised in section 1.2.4 against his and other single-valued feature theories.

3.0 Introduction

This chapter is devoted to some important aspects of the phonology of Ancient Greek. It consists of a characterization of the vowel system within underspecification theory and of an account of the rules providing the necessary evidence for the characterization proposed.

The variety of Greek being described is the Attic dialect as spoken between about 800 and 500 B.C. This dialect developed into 'classical' Attic, that is, the dialect of Athens and its vicinity (around 400 B.C.). At various stages in the discussion we will use evidence from outside the Attic dialect, but only when direct Attic evidence is unavailable.

The historical development of the Ionic-Attic vowel system will summon our prime attention in section 3.1, which deals with the major changes that took place between the end of the second millennium and the post-classical period (about 350 B.C.). The aim of this discussion is to establish the exact properties of the dialect to be described. Next, we will outline a proposal for the Attic vowel system as it existed between 800 and 500 B.C., along the lines of the underspecification framework developed in chapter 1. Arguments in favor of this particular theory will be put forward in section 3.3. The most compelling piece of evidence for our hypothesis will be postponed until chapter 4, in which we will deal with the description of vowel coalescence.

3.1 The diachronic evolution of the Ancient Greek vowel system

The Proto-Indo European vowel system is often assumed to have consisted of the vowels *e and *o, and possibly the long vowels *$\bar{e}$ and *$\bar{o}$. Furthermore, *i and *u are considered to have been allophones of the glides /y, w/. The Proto-Greek ten-vowel system *i, *e, *a, *o, *u, *$\bar{I}$, *$\bar{e}$, *$\bar{a}$, *$\bar{o}$, *$\bar{u}$ is the result of the loss of the Indo-European laryngeals *∂_1, *∂_2, *∂_3. In broad outline, the so-called laryngeal theory posits three laryngeals, where *∂_1 probably was [+constricted] (= /ʔ/), *∂_2 [+spread, +low] (= /h/), and *∂_3 [+spread, +round] (=/h^w/). In the last phase of Indo-European, the laryngeals disappeared with concomitant changes of the adjacent vocoids. These changes took roughly the following form:

(1) a:	∂_1eC > eC	∂_2eC > aC	∂_3eC > oC	b: $\partial_{1,2,3}$ iC > iC
	e∂_1C > $\bar{e}$C	e∂_2C > $\bar{a}$C	e∂_3C > $\bar{o}$C	i $\partial_{1,2,3}$ C > $\bar{I}$C

The simple ten-vowel system of Proto-Greek is preserved, or better, restored in a small group of dialects like, for instance, (i) the Arcado-Cypriot group, (ii) Lesbian and Thessalian, and (iii) the 'strict' Doric dialects. In most other dialects a system with seven, rather than five, long vowels arose. It seems plausible, however, that the dialects referred to under (i-iii) went through such a vowel system too (cf. Ruijgh 1984:67). In these dialects the sequences e+ey, o+ey show up as ey and oy, respectively, just as in Ionic-Attic, whereas e+e, e+o are contracted into [ɛ̄, ɔ̄] in the peripheral dialects and into [ē, ō] in Ionic-Attic. If the dialects under (i-iii) had not gone through a stage in which seven long vowels existed, we would have expected the long diphthongs *ɛ̄y and *ɔ̄y as the result of the former contractions. In the majority of these dialects the opposition between [ɛ̄, ē] and [ɔ̄, ō] had already been neutralized before the oldest inscriptions. In the Attic dialect, and by the same token in the Ionic dialect, the opposition between the long open and closed mid vowels persisted until approximately the post-classical period.

Towards the end of the second millennium B.C., Proto-Greek *ā was fronted to *$\overline{\text{ae}}$ in most Ancient Greek dialects, including the Ionic and Attic dialects. However, the front *$\overline{\text{ae}}$ was not very stable, and raising to [ɛ̄] took place around 550 B.C. at the latest. As a consequence of these changes the distinction between Proto-Greek *ē ([ɛ̄]) and *ā was neutralized.[1] An exception to this is the Attic dialect where the distinction remained after the sounds [r, i, e] because of the so-called "Rückverwandlung" (cf. péprāmay 'I am sold' vs. péprɛ̄may 'I am set on fire').

The most radical changes were caused by processes like Vowel Contraction and Compensatory Lengthening. The three-grade vowel system, containing only the mid vowels *e, *o, *ē, and *ō (phonetically [ɛ̄] and [ɔ̄]) expanded into a four-grade system in which four long mid vowels became distinctive: besides the open mid vowels [ɛ̄, ɔ̄] their closed counterparts [ē, ō] arose. Moreover, the vowel [ā] was reintroduced as a result of the same processes. We can establish the following relative chronology:

(2) a: First Compensatory Lengthening:

esmi	> ēmi	'I am'
krosnos	> krōnós	'spring, fountain'

b: Vowel Contraction:

treyes	> trê̄s	'three'
genea	> génɛ̄	'race'(n.a.pl.)

c: Second and Third Compensatory Lengthening:

pans	> pâ̄s	'all'
kalwos	> kālós (ion.)	'beautiful' (cf. att. kalós)

d: Vowel Contraction:

tīma-ete	> tīmâ̄te	'you honor'

These changes led to the Early Ionic-Attic vowel system in (3). We observe that the short vowel system remained relatively stable, while the long vowel system underwent some drastic changes:[2]

(3) Early Ionic-Attic (1000–800 B.C.)

	i	e	a	o	u	ī	ē	ɛ̄	ǣ	ā	ɔ̄	ō	ū
high	+	−	−	−	+	+	−	−	−	−	−	−	+
low	−	−	+	−	−	−	−	−	+	+	−	−	−
ATR	+	+	−	+	+	+	+	−	−	−	−	+	+
round	−	−	−	+	+	−	−	−	−	−	+	+	+
back	−	−	+	+	+	−	−	−	−	+	+	+	+

In the classical period (5th c.) the three-way contrast /ɛ̄, ǣ, ā/ was reduced to a two-way contrast /ɛ̄, ā/ by raising of /ǣ/. Consequently, the classical Attic vowel system can be represented as in (4):

(4) Classical Attic

	i	e	a	o	u	ī	ē	ɛ̄	ā	ɔ̄	ō	ū
high	+	−	−	−	+	+	−	−	−	−	−	+
low	−	−	+	−	−	−	−	−	+	−	−	−
ATR	+	+	−	+	+	+	+	−	−	−	+	+
round	−	−	−	+	+	−	−	−	−	+	+	+
back	−	−	+	+	+	−	−	−	+	+	+	+

Sommerstein (1973), Bubeník (1983) and Wetzels (1986) assume a slightly different classification of the classical Attic vowel system. They propose a system in which the long vowels /ɛ̄, ā, ɔ̄/ are specified as [+low]. This change in [low] allows an elimination of the feature [ATR], since it is fully redundant as can be concluded from the classification below:

(5) Classical Attic (alternative)

	i	e	a	o	u	ī	ē	ɛ̄	ā	ɔ̄	ō	ū
high	+	−	−	−	+	+	−	−	−	−	−	+
low	−	−	+	−	−	−	−	+	+	+	−	−
ATR	+	+	−	+	+	+	+	−	−	−	+	+
round	−	−	−	+	+	−	−	−	−	+	+	+
back	−	−	+	+	+	−	−	−	+	+	+	+

Either the feature specification in (4) or that in (5) is suitable for the analysis of vowel coalescence and related phenomena. In this thesis, we will assume the classification in (5), because it allows us to eliminate the feature [ATR]. However, nothing crucial hinges upon this decision. Below, in section 3.2, we will argue that the feature [back] is redundant, and that the features [high], [low] and [round] suffice to distinguish the underlying vowel system.

During the period up until 350 B.C. some additional developments occurred. First of all, the high round vowels were fronted to [ü, ǖ]. It is uncertain when exactly this change took place. According to Schwyzer (1939) it occurred quite early in the 7th century. Bartoněk (1966), however, suggests that the change was not fully accomplished until as late as 400 B.C. Schwyzer (1939:183) states that "Fürs Attische deutet auf Υ= ü die Schreibung ΚΥ [where Κ is the [-back] allophone of /k/, WdH], nicht ϘΥ [where Ϙ is the [+back] allophone of /k/, WdH] schon auf den ältesten Inschriften...". In diphthongs, whether underlying (basiléws 'king') or derived by contraction (êw 'well'), the off-glide remains a velar. At a later date, which cannot be determined with certainty, the second element of the diphthongs [aw, ew] developed a fricative pronunciation. We will take the observation that the off-glide remains a velar, particularly in cases where the diphthong is the result of vowel coalescence, as a strong indication that all round vowels were still [+back] at the time when vowel coalescence was productive. With respect to vowel coalescence proper, the fusion of two vowels into a single long vowel, the dorsal properties of the high round vowels are not particularly crucial, because high vowels are in general unaffected by this process.

The change of /ō/ to [ū] also took place in the post-classical period. Ruijgh (1984:71) argues that "au début du III^{e} s. av. J-C.,... ō n'avait pas encore abouti à ū fermé." This change is therefore irrelevant to the present discussion.

Finally, we will briefly discuss the status of the diphthongs. The long diphthongs /āy, ɔ̄y/ became monophthongs in the post-classical (Hellenistic) period. The development of /ɛ̄y/ is more complex. In lexicalized, non-transparent forms like klɛ̄ys > klēs 'key', lɛ̄ytōrgiā > lētōrgiā 'liturgy' the diphthong /ɛ̄y/ was changed into the half-closed monophthong. In derivationally transparent forms, on the other hand, the diphthong underwent the same change, but /ɛ̄y/ was restored by analogy. Subsequently, the long diphthong /ɛ̄y/ became [ɛ̄]. The long diphthongs /ēy, ōy/ did not come into existence in any of the Ancient Greek dialects, although we would have expected them to arise by means of vowel coalescence from e+ey and o+ey. These sequences, however, had already been altered by an independent phenomenon called hyphaeresis, which reduced a sequence of two mid vowels to a single short mid vowel before another vowel. The monophthongization of the homorganic diphthongs /ey, ow/ took place somewhere between the 7th and the 4th century B.C. It is usually assumed that this process, which caused the merger of ē and ey, and ō and ow, was not fully accomplished until 400 B.C.

Our main purpose is to give a full and adequate account of the mechanisms underlying the phenomenon of vowel coalescence in the Attic dialect in the light of the general theory outlined in chapter 2. In order to achieve this goal, we will ignore all post-classical developments discussed above, since, in many respects, they obscure the fundamental characteristics of vowel coalescence.

The process has been attested in the oldest inscriptions and the earliest literary texts (e.g. Homer). Furthermore, contraction was not operative in the Mycenaean period (cf. the Myc. spellings do-e-ro and me-zo-a$_2$ for, respectively, dô̄los 'slave' and mézdɔ̄ 'bigger' (nom. acc.pl.)). Hence, we may safely assume that the process was synchronically productive in the first half of the first millennium. Following the usual course of phonological changes, it gradually became obligatory, was subsequently morphologized and became more and more deeply embedded in the lexical phonology.

3.2 The representation of the Attic vowel system

In this section, a UT of Attic will be proposed along the lines suggested in chapter 1. Motivation for this approach will be put forward in sections 3.3 and 3.4, where phenomena like Augmentation, Perfect Reduplication, and Metathesis of Quantity will be discussed. In chapter 4, we will outline the implications of this theory for the description of vowel coalescence.

The first problem we face is the asymmetrical nature of the vowel system, that is, the existence of seven long vowels next to five short vowels. We saw in section 3.1 that the processes of Vowel Coalescence and Compensatory Lengthening are responsible for the additions in the long vowel inventory. Nevertheless, we will argue that the Attic vowel system is symmetrical underlyingly and consists of five short and five long vowels. One crucial observation is based upon the phonology of roots and stems. It turns out that roots or stems containing the long mid vowels [ē, ō] are extremely rare. They do occur in a small number of forms, for example dôlos 'slave', and the Ionic form ksênos 'stranger', where they arose as the result of vowel coalescence and compensatory lengthening, respectively. Besides these exceptional forms, however, the distinction between the open and closed mid vowels in the underlying vocabulary is negligible. Morpheme-internally, the long mid vowels are pronounced relatively open. The absence of this opposition in underived lexical items allows us to postulate a symmetrical vowel system in underlying representation. Consequently, in a theory of underspecification, the vowel system can be represented as in (6):

(6)

	i	e	a	o	u	ī	ē	ā	ō	ū
high	+				+	+				+
low			+					+		
round				+	+				+	+

This diagram conforms to the theory of minimal specification. We have argued in section 1.2 that this type of underspecification is not a priori preferable. In the vowel system in (6) the feature [high] is the only feature which distinguishes /i, u/ from /e, o/, and [round] is the only feature which distinguishes /i, e/ from /u, o/. Thus, [high] and [round] are distinctive within this class of sounds. In Steriade's (1987b) approach this would entail that both values are lexically specified. Deviations from this general strategy must be motivated. In the next section, it will turn out that such evidence is indeed available.

In diagram (6) the vocalic feature [back] remains fully unspecified. This feature is predictable and will be supplied by language-specific redundancy rules. The observation that the long mid vowels are pronounced relatively open can be explained quite easily by positing Stem Vowel Lowering (7):

(7) Stem Vowel Lowering: (SVL)

$$[-\text{high}] \rightarrow [+\text{low}] \;/\; [\ldots \underset{\text{V}\ \ \text{V}}{\underline{\;\wedge\;}} \ldots]_{\text{stem}}$$

Since SVL (7) mentions the feature [-high] in its structural description, the RROC proposed by Archangeli (1984) (cf. section 1.2) will activate the redundancy rules which supply the missing values for [high]. Hence, at this point in the discussion there seems to be little or no motivation for the absence of [-high] underlyingly. However, we will show that this process is ordered after several lexical rules which provide the missing evidence for the absence of this particular feature underlyingly.

Diagram (6) reveals that the mid vowel /e/ is fully unspecified. It is therefore predicted to be the default vowel, which we expect to exhibit some asymmetrical properties. In section 3.3 we will argue that this is indeed the case. The assumption that /e/ is the default vowel has some revealing implications for processes like Augmentation and Perfect Reduplication. In addition, it will turn out that several conditions on possible stem vowel alternations support the view that /e/ is the fully unspecified vowel.

The absent values in diagram (6) are supplied by a set of D-rules and R-rules, presented in (8):[3]

(8)

a: D-rules:		b: R-rules	
[ ]	→ [-high]	[+low]	→ [-high, +back]
[ ]	→ [-low]	[+high]	→ [-low]
[ ]	→ [-round]	[+low]	→ [-round]
		[αround]	→ [αback]

Stem Vowel Lowering has to be ordered among the redundancy rules in (8), and will be ordered after the D-rule supplying [-high] as well as after the R-rule supplying [-high, +back]. Of interest is the ordering relation between SVL and the D-rule supplying the value [-low]. These rules are disjunctively ordered by the Elsewhere Condition, because their outputs are distinct: SVL (the special case) will take precedence over the D-rule for [low]. We thus do not need to stipulate an extrinsic ordering relation between these rules.

3.3 Language-internal motivation for UT

Two types of arguments will be presented in favor of the underspecified vowel system. First of all, possible versus impossible stem vowel alternations will be discussed. Next, we will draw attention to three affixation processes, which support the hypothesis that /e/ is the default vowel. Finally, four phonological processes will provide corroborating evidence for the theory advanced.

3.3.1 Vowel Alternations

Ruijgh (1975:356) observes that stem vowel alternations take a particular shape in Attic: "on peut constater que l'une des deux voyelles alternantes est toujours ε: on trouve les alternances υ/ε, ι/ε, ο/ε, α/ε, mais non pas ι/α, ι/υ, υ/ο, ο/α..etc." Within the UT proposed the distinction between these possible and impossible alternations can be elegantly expressed. Compare the alternations in (9):

(9) a: V ~ V b: V ~ V c: V ~ V d: V ~ V

a: $\begin{bmatrix}+h\\+r\end{bmatrix}$ b: [+r] c: [+h] d: [+l]

astu-/aste- 'city' genos-/genes- 'race' poli-/pole- 'state' -ka-/-ke- (perf.suffix)

In all the stem vowel alternations, one of the alternants is /e/. Within UT, these vowel alternations take the form of a delinking of the vocalic features resulting in the fully underspecified vowel. The proposal that stem vowel alternation is obtained by delinking, explains why alternations like those in (10) are systematically excluded in Attic, since this type would imply both delinking and feature substitution:

(10) a: V ~ V b: V ~ V c: V ~ V d: V ~ V

a: [+h] [+b] b: [+h] $\begin{bmatrix}+h\\+r\end{bmatrix}$ c: $\begin{bmatrix}+h\\+r\end{bmatrix}$ [+r] d: [+r] [+l]

If only fully specified feature matrices were allowed, or if both feature values were specified for each segmental class in which a particular feature is distinctive, a complex set of rules would be needed to discriminate between permitted and excluded alternations. The assumption that the vowel /e/ is fully unspecified allows for a simple and insightful account of these facts.

3.3.2 Empty V-slots

Ancient Greek has two kinds of tense stems. A simplex tense stem is a verb stem which takes the endings (for mood and/or person/number/ voice) without further ado, e.g. phá-te (pres.ind.), phâ-y-te (pres.opt.) 'to say'. A complex tense stem is composed of a verb stem and a tense suffix, to which the endings are added, for instance, lū́-e-te (pres. ind.), lū́-se-te (fut.ind.), lū́-o-y-te (pres. opt.) and lū́-so-y-te (fut. opt.) 'to loose'. Below, we will be concerned with one important characteristic of most tense affixes: in underlying representation they contain the vowel /e/. It will be argued that surface deviations are best understood by assuming that the vowel /e/ is fully underspecified. We will discuss augment prefixation, reduplication prefixation, and tense formation.

The secondary tenses of the indicative mood (imperfect, aorist, pluperfect) are marked by an extension of the stem called the augment. This augment is prefixed to the verb stem. (11) contains some relevant examples taken from Goodwin (1894) and Schwyzer (1939):

(11)	1.sg.pres.ind.	1.sg.imperf.ind.	
a:	lū́ɔ̄	élūon	'loose'
	rhī́ptɔ̄	érrhīpton	'throw'
	gráphɔ̄	égraphon	'write'
	phílɔ̂	ephílɔ̄n	'love'
b:	ágɔ̄	ɛ̂gon	'lead'
	ethélɔ̄	ɛ́thelon	'wish'
	hoplízdɔ̄	hɔ̄́plizdon	'armor'
	hiketéwwɔ̄	hīkétewwon	'implore'
	hubrízdɔ̄	hū́brizdon	'insult'

The augment seems to take two forms: there is, first of all, a syllabic augment, which prefixes /e/ to consonant-initial stems, and secondly a temporal or positional augment, which lengthens the first vowel of verbs beginning with a vowel or the weak consonant /h/.

Theories allowing fully specified feature matrices only, require two prefixation rules to account for the forms in (11): one rule adding the vowel /e/ and one rule lengthening the stem vowel. If we adopt the UT developed here, these rules can be collapsed into one general augmentation rule, prefixing a bare V-slot to the verb. The formal representation of Augmentation is that of (12):

(12) **Augmentation:**

a: prefix V to the verb

b: associate the V-slot to the accessible vowel on the melodic tier

When the verb is consonant-initial, automatic spreading is blocked, since it would occasion a violation of the Well-Formedness Condition, which states that association lines between two tiers may not cross. As a consequence, the redundancy rules in (8) will be activated, deriving the default vowel /e/. Vowel-initial verbs, on the other hand, induce automatic spreading and the output will be a long vowel. Two sample derivations are presented in (13):

```
(13) a: -C V V-         V - C V V - V C         V C V V V C      (*V C V V V C)
         | \/    (12)       | \/    | |  (8)    | | \/  | |        `-|-\/  | |
         l  u               l  u    o n         e l  u  o n          l  u  o n

     b: -V C-           V - V C - V C               V V C V C
         | |     (12)    `--> | |  | |   /ā/-Fr      \/ | | |
         a g                  a g  o n               ɛ  g o n
```

The last step in (13b) illustrates an additional change: the fronting of /ā/ to [ɛ̄]. We will return to this phenomenon in section 3.3.3.3. The data in (11b) show that the lengthened mid vowels /e, o/ become [+low]. They therefore must feed into the rule of Stem Vowel Lowering discussed above. In section 3.3.3.1 we will argue that the theory of Lexical Phonology enables us to account for this change straightforwardly.

The major advantage of this analysis is that the behavior of both high and nonhigh vowels after Augmentation can be properly described. In both cases a long vowel is predicted in accordance with the facts. If, on the other hand, we had assumed that the augment is /e/, we would have wrongly predicted a diphthong. In that case, additional ad hoc assumptions would have been required as corrections.

Finally, let us discuss the class of verbs which have an initial /h/. As pointed out earlier, all consonants are blockers for the spreading operation, except /h/, which is transparent. We will assume, unlike Steriade (1982), that /h/ is linked to a C-slot of its own. However, it is only specified for the laryngeal features. In order to derive the correct surface forms, we must assume a rule of /h/-Migration which transfers /h/s occurring in intervocalic position to word-initial position. If the rule of /h/-Migration is ordered prior to the (b)-clause of (12) we can account for the /h/-initial verbs straightforwardly, as shown in (14):

```
(14) V -C  V  C  C  V  C  C-     C  V  V  C  C  V  C  C  V  C
        |  |  |  |  |  |  |      |  |  |  |  |  |  |  |  |  |
        *  *  *  *  *  *  *      *  *  *  *  *  *  *  *  *  *  root tier
        |  |  |  |  |  |  |      |   \ |  |  |  |  |  |  |  |
        h  |  |  |  |  |  |      h    \|  |  |  |  |  |  |  |  lar.tier
           |  |  |  |  |  |            |  |  |  |  |  |  |  |
           o  p  l  i  z  d            o  p  l  i  z  d  o  n  s.lar.tier
```

The assumption that the augment prefix is an empty V-slot, allows us to postulate one general Augmentation rule for the formation of the secondary tenses of the indicative. The behavior of vowel-initial, consonant-initial and /h/-initial verbs can be described without additional stipulations.

Not all forms can be derived by (12) and the application of independently necessary processes such as /ā/-Fronting and SVL. A small set of forms violate the general pattern. The forms in (15a) show a lengthened mid vowel which is [-low], and in (15b) the default vowel shows up before vowel-initial verbs:

(15)	1.sg.pres.ind.	1.sg.imperf.ind.	
a:	ékhɔ̄	ē̂khon	'have'
	hérpɔ̄	hē̂rpon	'creep'
	hélkɔ̄	hē̂lkon	'pull'
	ergázdomay	ērgazdómɛ̄n	'work, do'
b:	ɔ̄thɔ̄̂ (-ɔ̄théɔ̄)	eɔ̄́thɔ̄n	'push'
	idē̂n	êydon	'see'
	horáɔ̄	heɔ̄́rɔ̄n	'see'

The verbs in (15) take a syllabic augment, as if they have a consonant. For some of these forms a verb-initial /s/ may be posited synchronically, since in the aorist tense this consonant appears in éskhon, 'have' and hespómɛ̄n 'follow'. Sommerstein (1973) takes the existence of these forms as evidence for positing /sekh-/ and /sep-/ as the underlying forms. However, similar alternations are absent in the remaining cases. Two possible analyses seem available. The first is a fully abstract analysis in which it is arbitrarily assumed that the stems in (15) begin with an /s/, or in terms of CV Phonology, with an empty C-slot. The second option is that the verbs in (15a) are lexically marked with the rule feature [-SVL], and those in (15b) with the rule feature [-resyllabification]. We will not attempt to choose between these options, since the only important fact about the stems in (15) is that they are too few in numer to refute the analysis advanced.[4]

The second prefixation rule we want to discuss is Perfect Reduplication. The perfect, pluperfect and future perfect in all moods and in the participle and infinitive show reduplication, which marks the state resulting from the completion of the action expressed by the verb stem. The effects of reduplication are shown in (16):

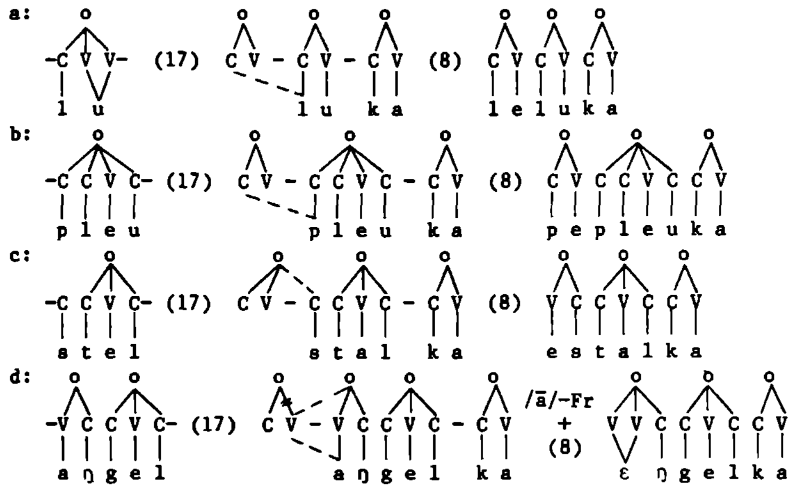
(16)	1.sg.pres.ind.	1.sg.perf.ind.		
a:	lū́ɔ̄	léluka		'loose'
	léypɔ̄	léloypa		'leave'
	khrī́ɔ̄	kékhrīka		'anoint'
	pléɔ̄	péplewka		'sail'
	pnéɔ̄	pépnewka		'blow'
b:	stréphɔ̄	éstropha		'turn'
	zdɛ̄tɔ̄̂	ezdɛ̄́tɛ̄ka		'seek'
	gnɔ̄rízdɔ̄	egnɔ̄́rika		'recognize'
	phthánɔ̄	éphthaka		'anticipate'
	rháptɔ̄	érrhammay	(Med.)	'stitch'
c:	aŋgéllɔ̄	ɛ̄́ŋgelka		'announce'
	ethélɔ̄	ɛ̄thélɛ̄ka		'wish'
	ophḗlɔ̄	ɔ̄phḗlɛ̄ka		'owe'
	hidrū́ɔ̄	hī́drūka		'place'
	hupháynɔ̄	hū́phaŋka		'weave'

Extensive analyses of Perfect Reduplication are given in Ruijgh (1972) and Steriade (1982). In both analyses syllable structure is held responsible for the two surface manifestations of this prefix. Steriade argues that the consonant clusters in (16a) are tautosyllabic, whereas the clusters in (16b) are not (cf. ma.kró 'long, big', ho.plɛ̄́ 'hoof' vs. ok.tɔ̄́ 'eight', as.tɛ̄́r 'star', mél.lɛ̄ma 'delay'). The first consonant in these forms is extrasyllabic, that is, not yet syllabified at the point in the derivation where reduplication takes place. This assumption enables her to formalize the process as follows:

(17) Perfect Reduplication: (PR)
   a. prefix CV to the stem
   b. associate the CV-slots left to right to the segmental melody of the first root syllable
   c. attach an empty V-slot to an inserted e

Steriade's account of PR distinguishes two subrules, the first of which prefixes a CV-template and the second of which inserts and associates an untimed e to the the available V-slot. Within the UT developed in this thesis the second subrule can be dispensed with, since the vowel quality is predictable. If the reduplication-V remains unassociated to the melodic tier, its content will be supplied by the redundancy rules in (8). Since we assume that Steriade's (1982) syllabification rules for Attic are correct, the forms in (17) can be derived as follows:

(18)



Some clarification may be in order here. The derivations in (18a,b) show the spreading of the stem-initial consonant to the accessible C-slot of the reduplication prefix, apparently deriving a geminate. These pseudo-geminates, however, do not exhibit the geminate blockage or inalterability properties of true ones: they are broken up by the application of the redundancy rules in (8). Following Hayes (1986a), we will assume that geminate blockage only holds for adjacent slots at the CV-tier. An interesting parallel to this can be found in vowel harmony systems involving neutral or transparent vowels. In such systems the harmonizing feature [aF] is spread across a neutral vowel, and, later in the derivation, the transparent vowel acquires the feature [-aF] by a redundancy rule. Kiparsky (1981) suggests the following fission operation to adjust the output of vowel harmony:

(19) C V C V_1 C V C → C V C V_1 C V C (V_1 = neutral vowel)
[αF] [αF] [−αF] [αF]

We suppose that this fission operation, which probably is a subcase of the more general tier conflation mechanism (cf. McCarthy 1986), is also responsible for the geminate split in (18a,b). The derivations in (18c,d) show that when verbs are vowel-initial or begin with an extrasyllabic consonant, the C-slot of the reduplication prefix is not realized phonetically, leaving one wondering why the empty C-slot is not realized as the default consonant. A closer look at the forms in (16b,c) reveals that reduplication and augmentation are indistinguishable in these forms. Ruijgh (1972) therefore proposes to derive these forms by Augmentation instead of reduplication. He states: "le redoublement est un élément constitué par un homophone de l'augment, précédé de la consonne initiale du thème dans le cas où cet homophone constitue une syllabe brève" (Ruijgh 1972:213). Assuming that this analysis is correct, one avoids the problem raised by the empty C in the examples (16b, c). However, in order to describe the reduplication facts, we must slightly complicate the (a)-clause of (17) above. The revised reduplication format is given in (17'):

(17') Perfect Reduplication: (revised)

$<C>_a$ V + $<_o[C>_b$ if a then b

Evidence for this version of Perfect Reduplication is not hard to find. First, the examples in (16c) show that a lengthened /a/ undergoes /ā/-Fronting to [ɛ̄], and lengthened mid vowels become [+low], just as lengthened /e, a, o/, by Augmentation. Second, the set of vowel-initial verbs whose lengthened vowels do not undergo SVL, is the same as the set of verbs to which an /e/ is prefixed, as if they were consonant-initial. Some relevant examples are given in (20):

(20) a:	helíttɔ̄	ḗliksa (aor.)	ḗliŋmay (perf.Med.)	'roll'
	hélkɔ̄	ḗlkusa (aor.)	ḗlkuka (perf.Act.)	'pull'
	ékhɔ̄	ē̂khon (imperf.)	---	'have'
	eɔ̄̂	ḗɔ̄n (imperf.)	ḗāka (perf.Act.)	'permit'
b:	ɔ̄thɔ̄̂	éɔ̄sa (aor.)	éɔ̄smay (perf.Med.)	'push'
	halískomay	heā́lɔ̄n (aor.)	heálɔ̄ka (perf.Act.)	'be captured'
	horáɔ̄	heɔ̄́rɔ̄n (imperf.)	heórāka (old form)	'see'
			heɔ̄́rāka (new form)	

The final piece of evidence for empty-V affixation may be derived from the tense suffixes which consist of or end in a theme vowel. The thematic present/imperfect, the thematic or second aorist Active and Medium, all futures, and the future perfect are formed in this way. The quality of this vowel is largely predictable. It is /e/, except when the personal ending begins with a nasal consonant, in which case the theme vowel undergoes rounding to [o] (cf. section 3.3.3.2). Furthermore, before the optative marker -y- the theme vowel is /o/. The subjunctive mood is marked by the lengthened allophones of the theme vowel [ɛ̄] or [ɔ̄], where [ɔ̄] occurs under the same circumstances. Some examples are given in (21):

(21) a:	lége-te, légo-men	'say'
	pháyne-te, --o-men (←phan-$y^e/_o$)	'show' (cf. phanɔ̄̂)
	gɛ̄ráske-te, —o-men (←gɛ̄ra-$sk^e/_o$)	'grow old' (cf. gɛ̄rā́somay)
b:	lékse-te, lékso-men (←leg-$s^e/_o$)	'say' (fut.)
	elége-te, elégo-men	'say' (imperf.)
	elípe-te, elípo-men	'leave' (2.aor.)

By assuming that these tenses are formed by adding a tense suffix consisting of an empty V, we can derive the phonetic surface forms through application of the redundancy rules in (8). When the verbal stem ends in a nonhigh vowel, the stem vowel and theme vowel are merged into a long vowel. Fusion becomes even more plausible if the theme vowel is fully underspecified. These contract verbs will receive ample attention in the next chapter.

In summary, we have shown that affixation processes such as Augmentation, Perfect Reduplication and Tense Formation provide strong evidence for the claim that the vowel /e/ is the default vowel in Attic. In the immediate environment of another V, the two vowels merge into a long monophthong, while elsewhere the mid vowel /e/ appears. Within UT this relationship becomes perfectly obvious, since adjacent to a V an empty V is susceptible to automatic spreading, while in other environments this V-slot receives its phonetic interpretation by the redundancy rules in (8).

3.3.3 The main vowel rules

Following Kiparsky (1982, 1985) and Archangeli (1984), we have proposed to apply the redundancy rules as late as possible. The ordering relations between these rules and the P-rules proper are determined by general principles such as the Elsewhere Condition and the Redundancy Rule Ordering Constraint. As a consequence of this approach, we can distinguish two types of P-rules, viz. those which are feature changing and those which are feature filling. Below, several lexical processes will be discussed that can be satisfactorily described within this theory. It will turn out that some of these rules apply in both derived and underived lexical forms. In a theory of full specification and the theory of Lexical Phonology (cf.section 1.4), we expect that the lexical rules which are interspersed with morphology are restricted to derived environments. One disadvantage of constraining lexical rules in this way is that we have to posit morpheme structure conditions besides P-rules to explain a single generalization. This problem is usually referred to as the duplication problem (cf. Kiparsky (1982) for more details). The theory of underspecification allows us to solve this problem elegantly. If we state these lexical rules as feature-filling rules, they are allowed to apply in underived lexical items, if they do not violate Kiparsky's (1982) version of the Elsewhere Condition (or Hermans' (1986, forthcoming) interpretation of the Projection Principle). Hence, if feature-filling nonneutralization rules may apply to underived lexical items, we do not have to posit two separate mechanisms to explain a single phenomenon.

3.3.3.1 Stem Vowel Lowering and Stem Vowel Shortening

Stem Vowel Lowering (SVL) has been formulated here as a morpheme structure condition that marks all nonhigh long vowels redundantly as [+low]. Moreover, we have seen that vowel-initial verbs to which the augment is added show the same property. We repeat some relevant examples in (22):

(22) a: underived lexical items

/khōrā-/	→ [khɔ̄rā-]	'land'
/nēso-/	→ [nɛ̄so-]	'island'

b: derived lexical items

/V+ethel+on/	→ [έthelon]	(imperf.)	'wish'
/V+hoplizd+on/	→ [hɔ́plizdon]	(imperf.)	'armor'
/lū+oV+men/	→ [lúɔ̄men]	(subj.)	'loose'

Hence, the short-long distinction is accompanied by a closed-open alternation. This relationship between vowel length and vowel quality is widespread in Attic. Verbal stems ending in a nonhigh vowel exhibit the same twofold alternation:

(23) a:	hísta-men (1.pl.pres.ind.)	-	hístε̄-mi (1.sg.pres.ind)	'set'
	títhe-men	-	títhε̄-mi	'place'
	dído-men	-	dídɔ̄-mi	'give'
b:	tīmá-e-te (= tīmâte)	-	tīmέ-s-e-te (2.pl.fut.)	'honor'
	philé-e-te (= philête)	-	philέ-s-e-te	'love'
	dε̄ló-e-te (= dε̄lôte)	-	dε̄lɔ́-s-e-te	'manifest'

Third-declension [+animate] nouns show the same type of alternation. The nominative singular masculine and feminine have [ε̄, ɔ̄], while the remaining forms in the paradigm have [e, o]. The long vowel in the nominative singular is always [+low], while its short counterpart is redundantly [-low]:

(24) léɔ̄n	-	léon	(voc.sg.)	'lion'
rhέtɔ̄r	-	rhέtoros	(gen.sg.)	'orator'
sɔ̄krátε̄s	-	sɔ̄krátey	(dat.sg.)	'Socrates'
patέr	-	patéra	(acc.sg.)	'father'

We can observe, however, that the relation between vowel length and vowel quality is not absolute. The forms in (23b) undergo vowel coalescence (e.g.phile-e-te → philête, dε̄lo-e-te → dε̄lôte). Long vowels which arise through compensatory lengthening do not become [+low] either (cf. esmi → ēmi 'I am', -onsi → -ōsi, ending of 3.pl.). We thus have to order SVL before the processes of Vowel Coalescence and Compensatory Lengthening. Furthermore, we must prevent SVL from reapplying at a later cycle, because otherwise it would destroy the effects of these processes.

The distinction between the long half-open vowels - which arise by means of Augmentation and SVL - and the long half-close vowels - which are the result of Vowel Coalescence and Compensatory Lengthening - provides significant motivation for a level-ordered lexicon in Attic. If we assume that the augment is added to the verbal stem at level 1,[5] whereas the tense-marking suffixes are added at level 2, we can explain the open-close alternations straightforwardly, if SVL is a level-1 rule. Thus, the future, aorist and imperfect of eleɔ̂ 'I pity' are assigned the following morphological structure, where the subscripts indicate the level at which morphological concatenation takes place:

(25) a: [[eleē]$_1$ sɔ̄]$_2$ → eleɛ́sɔ̄ (1.sg.fut.ind.Act.)
b: [[V[eleē]]$_1$ sa]$_2$ → ɛ̄léɛ̄sa (1.sg.aor.ind.Act.)
c: [[[V [ele]]$_1$ e] te]$_2$ → ɛ̄leɛ̂te (2.pl.imperf.ind.Act.)

For nouns, we will assume that the root and noun-forming suffixes are derived at level 1, whereas the case endings are attached at level 2. These assumptions enable us to explain alternations of the type tīmɛ̄́n (acc.sg.) vs. tīmā́s (acc.pl.) 'honor'. At level 1, the action-noun suffix -mā is added to the root tī in the singular (the long /ā/ undergoes the rule of /ā/-Fronting, cf.3.3.3.3). The accusative singular ending [-n] is added at level 2. In the plural, the rule of Stem Vowel Shortening will produce [tīma] to which /ā/-Fronting cannot apply. At level 2, the accusative plural ending [-Vs] is attached, and at this point the two adjacent vowels undergo Vowel Coalescence into /ā/, which can no longer be fronted to [ɛ̄]. We will return to the relationship between /ā/-Fronting and Vowel Coalescence in greater detail in chapter 4. Similarly, the nominative singular form rhɛ̄́tɔ̄r 'orator' is formed at level 1 by concatenation of the verbal root -rhɛ̄- and the noun-forming suffix -tɔ̄r-. By applying SVL we derive the correct surface form.

In (26) below, Stem Vowel Lowering is reformulated in accordance with the principles of Lexical Phonology, which do not allow us to refer to notions like 'stem' in the structural description of phonological rules. The stipulation that SVL is a level-1 rule is sufficient:

(26) Stem Vowel Lowering (final version)
$[-\text{high}] \rightarrow [+\text{low}] \; / \; \underset{\text{V V}}{\underline{\quad}}$ [level-1 rule]

SVL interacts with a rule responsible for the length alternations shown in (23) and (24) above. At first sight, either a shortening or a lengthening analysis would appear to be possible. We will suggest, however, that the shortening analysis is preferable.

In one class of verbs, certain stem-internal modifications take place, which are usually referred to as ablaut (cf. Schwyzer 1939:354-365), although a distinction must be made between qualitative and quantitative ablaut, and between the e-phase and the o-phase (='Grundstufe'), ē-phase and ō-phase (='Dehnstufe'), and Ø-phase (='Schwundstufe'). In broad outline, verbs whose stems end in plosives can be divided into two groups: (i) those having e-phase and o-phase, and (ii) those having [ī, ā, ū]. These strong forms show up in all tenses, except in the second or thematic aorist and the second passive or 'ɛ̄-aorist', where the reduced vowels [i, u, a] occur. The following forms show these alternations:

(27) a: léypɔ̄ - élipon - léloypa 'leave'
péythomay - epithómɛ̄n - pépoytha 'obey, trust'
b: phéwgɔ̄ - éphugon - péphewga 'flee'
péwsomay (fut.) - eputhómɛ̄n - pépusmay 'hear, inquire'

c:	tḗkɔ̄	- etákɛ̄n	- tétɛ̄ka	'melt'
	lɛ̄́sɔ̄ (fut.)	- élathon	- lélɛ̄tha	'escape the notice of'
d:	trī́bɔ̄	- etríbɛ̄n	- tétripha	'rub'
	phrū́gɔ̄	- ephrúgɛ̄n		'broil'

The forms in (27) can be elegantly described by a rule that shortens stem vowels. The vowel in a stem such as leyp- is distinct from that in trīb-, while the reduced vowels in lip- and trib- are nondistinct. The reduced form is therefore predictable from the strong form, but not vice versa. If, instead, we were to assume a rule of stem-vowel lengthening, we would have to specify the quality of the inserted vowel. In the case of /lip-/, for instance, the inserted vowel must be specified as /e/ in the present tense, and as /o/ in the perfect.

Another argument favoring the shortening analysis comes from the productive formation of deverbal nouns which show the strong form of the verbal stem (cf. lêymma 'remainder, surplus', élleypsis 'fall short', phêwksis 'escape').[6] The simplest analysis is the one in which the strong forms are taken as underlying, since then we can form nouns without any further changes.

The existence of two types of first-declension nouns, viz. those which end in a long vowel and those which end in a short vowel in the nominative, vocative and accusative singular, provides additional evidence for the vowel-shortening approach. Some relevant examples are given in (28):

(28)	nom.sg.	acc.sg.			nom.sg.	acc.sg.	
a:	khɔ̄́rā,	khɔ̄́rān	'land'	b:	thálatta,	thálattan	'sea'
	skiā́,	skiā́n	'shadow'		géphūra,	géphūran	'bridge'
	tīmɛ̄́,	tīmɛ̄́n	'honor'		hámilla,	hámillan	'contest'

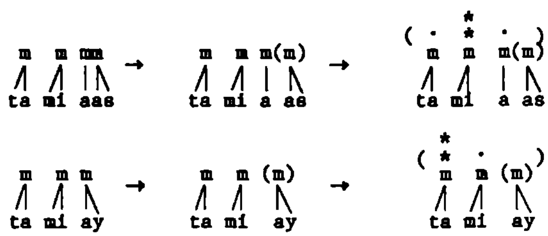
In the plural and the genitive/dative singular, the distinction between the nouns in (28) is neutralized. The noun stems always end in a short /a/ as is shown by the nominative plural forms khɔ̂ray, tīmáy, thálattay and géphūray. Under a vowel-lengthening analysis, we cannot discriminate between the nouns in (28). A lengthening rule would predict a long stem vowel in the singular of both classes. If we assume that the length opposition is basic, and furthermore posit a vowel-shortening rule which takes the plural stems as its input, we can derive the first-declension nouns without any further stipulation.

Our final argument is based on the accent pattern of the first-declension nouns. De Haas and Hermans (forthcoming) argue that accentuation in Attic is syllable-based and quantity insensitive. The claim that the Attic accent system is quantity insensitive is seemingly too strong, in the light of alternations such as thálatta (nom.sg.) vs. thaláttɛ̄s (gen.sg.) 'sea' and ánthrɔ̄pos (nom.sg.) vs. anthrɔ̄́pō 'man'. We argue, however, that reference to quantity can be avoided if the right-peripheral mora is marked as extrametrical. The nominative plural forms in (29) below seem to refute this claim. In the plural, the noun stem ends in a short vowel, unlike the singular (see above), although the accent patterns are identical:

(29) a:	tīmḗ (nom.sg.)	b:	tīmáy (nom.pl.)	'honor'
	skiā́		skiáy	'shadow'
	tamíās		tamíay	'steward'
	kritḗs		kritáy	'judge'

By marking the last mora of the forms in (29) as extrametrical, accent shift is expected to take place in the nominative plural, since the stem vowel is short. Hence, we predict *[támiay] and *[tî̄may], as the derivation in (30b) below illustrates.[7] In the grid theory proposed by Hayes (1987) we can state the Attic accent rule as follows: (i) mark the right-peripheral mora as extrametrical; (ii) from right to left, parse a word into syllabic trochees, and (iii) form a higher level constituent which gets its grid mark assigned by End Rule Final:

(30) a:



= [tamíās]

b:

= *[támiay]

We account for the absence of accent shift by assuming that vowel shortening is ordered after the accent rules, following a suggestion in Ruijgh (1975). A similar account of the stress facts cannot be maintained if the noun stems end in a short vowel underlyingly. Since there is no reason to believe that the analysis proposed is wrong, we use it here as an indirect argument in favor of underlyingly long vowels.

The verbs exhibiting strong and weak forms, the deverbal nouns which have the strong verbs as their basis, the first-declension nouns of the type khṓrā versus géphūra, and the accent patterns of the nouns in (29) provide strong evidence for the vowel shortening approach. Just like Stem Vowel Lowering (26), this shortening process only applies to stems. In other words, the application domain of Stem Vowel Shortening must be confined to level-1. We can formalize the rule as in (31):

(31) Stem-Vowel Shortening [level-1 rule]
$V \rightarrow \emptyset \ / \ [\text{—}\ V]_0$ in certain morphological environments

Stem Vowel Shortening states that the left-hand V-slot of a tautosyllabic vowel sequence is deleted. This formalization enables us to derive the weak stems /lip-/ (~ /leyp-/) 'leave' and /trib-/ (~ trīb-) 'rub' by the same rule.

3.3.3.2 Theme Vowel Rounding

Above, we have argued that certain tense suffixes consist of or end in a theme vowel. This vowel takes two forms in the indicative, subjunctive and imperative.[8] If the personal ending begins with a nasal consonant, the theme vowel becomes [+round], and otherwise it shows up as the default vowel /e/. These alternants thus appear in complementary environments. This distributional difference can be described easily within the present UT by positing Theme Vowel Rounding (32):

(32) Theme Vowel Rounding

$$[+\text{THEME}] \rightarrow [+\text{round}] \; / \; \text{—} \;\; [+\text{nas}]$$

The subjunctive is marked by lengthening of the thematic vowel. The data in (33) show that (32) applies irrespective of vowel length. This is exactly what is expected under the Inalterability hypothesis proposed by Hayes (1986a), since the rule only refers to one tier in its structural description, and as a consequence the LC will not play a role.

(33) a: lū́ɔ̄men	(1.pl.)	b: lū́ɛ̄te	(2.pl.)	'loose'	(pres.subj.Act.)
lū́sɔ̄men	(1.pl.)	lū́sɛ̄te	(2.pl.)	id.	(aor.subj.Act.)
lū́sɔ̄may	(1.sg.)	lū́sɛ̄tay	(3.sg.)	id.	(aor.subj.Med.)

In many respects, the rule of Theme Vowel Rounding resembles Backing in Lithuanian (cf. Kenstowicz 1970, Hayes 1986a). In this language, the vowels /e, ē/ are converted into [o, ō] before the vowel /u/ or the glide /w/. CV Phonology allows us to describe both processes in a similar fashion, as is shown in (34):

(34) a: $$\begin{array}{cc} V & X \\ | & | \\ e & u \end{array} \rightarrow \begin{array}{cc} V & X \\ | & | \\ o & u \end{array} \qquad \begin{array}{cc} V\,V & X \\ \vee & | \\ e & u \end{array} \rightarrow \begin{array}{cc} V\,V & X \\ \vee & | \\ o & u \end{array} \qquad \text{(Lithuanian)}$$

b: $$\begin{array}{cc} V & C \\ | & | \\ e & N \end{array} \rightarrow \begin{array}{cc} V & C \\ | & | \\ o & N \end{array} \qquad \begin{array}{cc} V\,V & C \\ \vee & | \\ e & N \end{array} \rightarrow \begin{array}{cc} V\,V & C \\ \vee & | \\ o & N \end{array} \qquad \text{(Attic)}$$

There is one other set of empirical facts which are relevant to the discussion of Theme Vowel Rounding. In the third person plural, the round allophone of the theme vowel appears before a nonnasal consonant (cf. lū́ōsi 'they loose'). In the remainder of this section we will briefly go into this matter. We will argue that it is possible to motivate an underlying nasal consonant here.

Our argument is based on paradigm congruity, and in order to see this, let us review the person/number/voice endings of the inflected verb. There are two main classes of endings: one for the active voice and one for the medio-passive. Each individual class is subdivided into endings appearing in the primary tenses and those appearing in the secondary tenses. The survey of the person/number/voice endings in (35) - which is based on the verbs in the mi-conjugation - shows that the two main classes are clearly akin. Generally speaking, they differ from one another in the vowels, whereas the initial consonants are similar:

(35)

	Active		Medio-passive	
	prim.tenses	sec.tenses	prim.tenses	sec.tenses
	(pres.ind.)	(pres.opt.)	(pres.ind.)	(imperf.ind.)
1.sg.	phɛ̄+mí	hīéyyɛ̄+n	déyknu+may	edeyknú+mɛ̄n
2.sg.	phɛ̄+s/phɛ̄́+ys	hīéyyɛ̄+s	déyknu+say	edéyknu+so
3.sg.	phɛ̄+sí	hīéyɛ̄	déyknu+tay	edéyknu+to
1.pl.	pha+mén	hīêy+men	deyknú+metha	edeyknú+metha
2.pl.	pha+té	hīêy+te	déyknu+sthe	edéyknu+sthe
3.pl.	phā+sí	hīêy+en	déyknu-ntay	edéyknu+nto
	'say'	'send'	'show'	

Apparent exceptions to this generalization are the third person singular and plural. We can observe that the [t] which appears in the medio-passive alternates with [s] in the present indicative active. Important in this respect is the environment in which [t] and [s] appear. The [t] shows up before back vowels, while [s] shows up before high front vowels. This kind of alternation is common in human languages (cf. Dutch adop[t]eren 'adopt' vs. adop[s]ie 'adoption' or their English equivalents). We will assume a palatalization rule which, among other things, changes /t/ into [s] in the appropriate environment. In addition, in the secondary tenses active and in the primary and secondary tenses medio-passive, a nasal consonant shows up in the third person plural, whereas this /n/ is absent from the primary tenses active. In this case the absence of /n/ is compensated for by the lengthening of the preceding vowel. The important question is why /n/ is absent from the primary tenses active, but not the other tenses. To answer this question appropriately, we first have to consider the examples in (36):

(36) a:	pantós (gen.sg.masc.)	b:	pâs (←pant-s) (nom.sg.masc.)	'all'
	mélanos		mélās (←melan-s)	'black'
	léontos		léōsi (←leont-si) (dat.pl.)	'lion'
	lúontos		lûon (←lūont) (nom.sg.neut.)	'loosing'
			lúōsi (←lūont-si) (dat.pl.)	

These examples have the following properties. First, stems ending in an /nt/ cluster lose the /t/ word-finally and before a consonant. Furthermore, the nasal stop is deleted before /s/ accompanied by lengthening of the preceding short vowel. Hence, the form lúōsi (3.pl.pres.ind.Act.), and the form léōsi (dat.pl.part.masc./neut.) (cf. lúontay, léontos) can be derived in similar ways, as is illustrated in (37):

(37)	/lū-V-nti/	/lū-V-ntay/	/leont-os/	/leont-si/	/phā-ti/	/melan-s/
(32)	o	o	—	—	—	—
Palat.	s	—	—	—	s	—
Vns→ V̄s	ō	—	—	ō	—	ā
	[lúōsi]	[lúontay]	[léontos]	[léōsi]	[phɛ̄sí]	[mélās]

Confirmation of this analysis can be obtained from the adjectives and participles, which have the masculine and neuter case endings of the third declension, and the feminine ones of the first. In addition, in the feminine -ya is added to the stem (cf. glukú-s (nom.sg. masc.), gluké-os (gen.sg.masc.) versus glukê-ya (nom.sg.fem.), gluké-yā-s (gen.sg.fem.) 'sweet'), and the addition of -ya is responsible for the same set of changes as those discussed above. The gen.sg. forms in (38) show these changes clearly:

(38) a:	mélanos	vs.	meláynɛ̄s	(←melanyās)	'black'
	pantós		pásɛ̄s	(←pantyās)	'all'
b:	lúontos		lūósɛ̄s	(←lūontyās)	'loosing'
	histántos		histásɛ̄s	(←histantyās)	'erecting'

The adjectives and participles show that the /nty/ cluster does not show up in the feminine. The /t/ changes into [s] under influence of a following yod, and the yod itself deletes. Furthermore, the /n/ disappears before this secondary [s], and the preceding vowel lengthens. Hence, confining ourselves to the feminine paradigm, we cannot account for the appearance of [s] and the preceding long vowel. The comparison with the masculine and neuter paradigm makes these phenomena fully transparent. Similarly, if we were to restrict our attention to the person/number endings in the active, the third person endings would look rather exceptional, but the person/number endings in the medio-passive reveal that the third person endings are derived from underlying /ti/ and /nti/.

We conclude from the preceding discussion that forms such as lúōsi 'they loose' and phérōsi 'they bear' take the following underlying representation: /lū-o-nt-i/ and /pher-o-nt-i/, where -nt- marks the third person plural, and -i marks the active voice. In the forms lúontay, and phérontay, the morpheme -nt- also marks the third person plural, and -ay marks the medio-passive voice.

3.3.3.3 /ā/-Fronting

/ā/-Fronting was already referred to in passing when we discussed Augmentation and Perfect Reduplication. The fronting of /ā/ to [ɛ̄] is the synchronic residue of the fronting of Proto-Greek *ā to *ǣ and its subsequent raising to [ɛ̄]. This fronting gave rise to numerous alternations in Attic. In (39) below, the most important ones are listed:

(39) a: Augmentation

agɔ̄	ɛ̂gon	ɛ̂ŋmay[9]	'lead'
aŋgéllɔ̄	ɛ́ŋgēla	ɛ́ŋgelka	'announce'

b: Vowel Coalescence

géney	génɛ̄	(-gene-a)	'race'
sɔ̄krátey	sɔ̄krátɛ̄	(-sɔ̄krate-a)	proper name

c: length alternations in root-tense stems of mi-verbs

hístamen (1.pl.pres.ind.)	hístɛ̄mi (1.sg.pres.ind.)	'set'
phamén	phɛ̄mí	'say'

d: length alternations in the aorist

pháynɔ̄	éphɛ̄na		'show'
katháyrɔ̄	ekáthɛ̄ra		'clean'

e: length alternations in first-declension nouns

thálatta (nom.sg.)	thaláttɛ̄s (gen.sg.)		'sea'
kritá (voc.sg.)	kritɛ́s (nom.sg.)		'judge'
tīmáy (nom.pl.)	tīmɛ́		'honor'

f: length alternations in compounds

akestós	'curable'	an-ɛ́kestos	'incurable'
akowstós	'audible'	an-ɛ́kowstos	'inaudible'

g: length alternations in derivation

lanthánɔ̄	'escape the notice of'	lɛ́thɛ̄	'forgetfulness'
lambánɔ̄	'take'	sul-lɛ́bdɛ̄n	'collectively'

It will be clear then that Attic has a rule of /ā/-Fronting, which, however, is restricted to certain environments. First, contractions of the type a+e must be exempted from undergoing the rule (e.g. /tīma-e-te/ → [tīmâte] 'you honor'). Second, long /a/s arising from the Second Compensatory Lengthening also resist fronting (e.g. /pans/ → [pâs] 'all'). Finally, and in this respect Attic crucially differs from the Ionic dialect, /ā/ fails to front if it is preceded by [e, i, r] as the comparison between Attic and Ionic in (40) indicates:

(40) Attic	Ionic	
geneā́	geneɛ̄́	'family'
néā	néɛ̄	'new' (fem.)
oykíā	oykíɛ̄	'house'
hɛ̄mérā	hɛ̄mérɛ̄	'day'
khɔ̄́rā	khɔ̄́rɛ̄	'land'
prā́ttɔ̄	prɛ̄́ssɔ̄	'do'

Sommerstein (1973:55) makes an attempt to account for the fronting facts by positing the Low Vowel Rule (41),

(41) Low Vowel Rule

$$\begin{bmatrix}+\text{long}\\+\text{low}\\-\text{round}\end{bmatrix} \rightarrow [-\text{back}] \;/\; \begin{Bmatrix}[+\text{back}]\\ \\ [-\text{high}]\end{Bmatrix} \;\_\_$$

which expresses that /ā/ is changed into [ɛ̄] after [+back] segments as well as after [-high] ones. However, this rule does not account for the fronting of word-initial /ā/s in (39a). Furthermore, he must assume that the liquid [r] is (still) palatalized, i.e. [+high], an assumption for which no independent evidence is available. In addition, Schwyzer (1939), Lejeune (1972), Ruijgh (1976) and Bubeník (1983), among others, point out that the conditioning behavior of [r] is much more restricted than that of the front vowels. Ruijgh (1976:577-578) states: "D'abord, tout ā y a abouti à $\overline{ae}$; plus tard, $\overline{ae}$ est redevenu ā après r; plus tard encore, après la chute de w et la contraction de ea en $\overline{ae}$, la voyelle $\overline{ae}$ a abouti à ā après e et i et à ɛ̄ dans les autres positions." In (42) below, a few examples show the difference between [r] on the one hand

and [e, i] on the other. Moreover, Sommerstein assumes that forms like néā 'new' (fem.) are derived from underlying forms containing an intervocalic yod. Once again, we know of no independent motivation, neither synchronically nor diachronically (<néwā). Hence, his attempt to reduce the environment in which /ā/ fails to front to a natural class is far from convincing. The forms in (42) seem to indicate that the synchronic rule of /ā/-Fronting is a telescoping of historically distinct processes.

(42)	a:	ore-a	→ órɛ̄	'mountain'(nom.acc.pl.)
		mere-a	→ mérɛ̄	'share'
	b:	endee-a	→ endeā̂	'lacking'
		hugie-a	→ hugiā̂	'healthy'
	c:	korā	→ kórɛ̄	'girl' (ion. kṓrɛ̄)
		derā	→ dérɛ̄	'neck' (ion. dērɛ̄́)
		geɔ̄métrās	→ geɔ̄métrɛ̄s	'(land) surveyor'
	d:	neātos	→ neātós	'development of fallow (land)'
		thāā	→ théā	'spectacle'

All underlying /ā/s, except those after [r, i, e] undergo the fronting rule, while /ā/s from e+a-contraction undergo fronting, unless a front vowel precedes. The forms in (42c) are exceptional, since fronting takes place in spite of a preceding [r]. We will not examine the conditions imposed on the rule of /ā/-Fronting in full detail here, and only suggest a possible way to account for the fronting facts.

Zonneveld (1978), among others, proposes to deal with exceptions to phonological rules by adding so-called diacritic rule features to the lexical representation of exceptional forms. Two logical situations are possible: (i) lexical items unexpectedly fail to undergo a P-rule, or (ii) lexical items unexpectedly undergo a P-rule. We can refer to the former situation as underapplication and to the latter as overapplication.

For the Attic forms we have to invoke the overapplication option. If we assume that /ā/-Fronting applies after e+a-contraction and the first compensatory lengthening (cf. chapter 4), we can account for most facts, except those in (42a,c). By marking these forms as [+/ā/-Fronting], the rule will overapply to these cases. As a consequence, we predict that forms like órɛ̄, kórɛ̄..etc. are highly marked. This seems to be the correct prediction. Adjectives have two or three endings, and the choice appears to be determined by the gender of the noun. Hence, the surface form of adjectives is transparent in this respect. It turns out that fronting fails to take place after [r] without exception in adjectives of the type ayskhrā́, the feminine form of ayskhrós 'ugly, disgraceful'. This is expected, since the gender specification of adjectives is taken care of in the syntactic component, while /ā/-Fronting is clearly a lexical rule.

Thus, we can restate Sommerstein's Low Vowel Rule as in (43) below, in which we have not tried to reduce the segments [r, i, e] to a genuine natural class:

(43) /ā/-Fronting

$$[+\text{back}] \rightarrow \emptyset \; / \; X \; V \; V$$

* place tier

— dorsal tier

Condition: $X \neq r, i, e$

/ā/-Fronting is a typical example of a structure-dependent rule. First, it crucially refers to the melody and the CV-tier. The Linking Constraint allows only long vowels specified as [+back] to undergo the rule. Furthermore, the rule refers to segment-internal hierarchy. The LC predicts that /ā/-Fronting applies to a representation if and only if the place node is uniquely linked to the dorsal node specified as [+back]. As a consequence, the rule will not treat all back vowels alike. The round back vowels are immune to the rule, since in their representations the place node is linked to the labial node as well as the dorsal node. Hence, /ā/-Fronting provides additional evidence for the claim that the LC holds for all structure-dependent rules. In other words, rules which mention segment-internal structure in their structural description should not be exempted from this universal constraint. In addition, the rule also provides indirect evidence for the theory of underspecification, because only in such a theory is it profitable to invoke the LC. The latter in turn, enables us to achieve important simplifications in the statement of phonological rules.

In summary, four lexical processes have been discussed and formalized within the UT outlined in section 1.2. The analysis proposed must be preferred to alternative approaches in which features are fully specified. Rules like Stem Vowel Lowering and Stem Vowel Shortening apply in derived as well as underived lexical items. In a theory of full specification, we are forced to posit morpheme structure conditions to account for the changes in underived forms and a P-rule proper to account for the same changes in derived lexical items, that is, a theory of full specification is faced with problems of duplication. On the assumption that feature-filling rules may apply to both derived and underived forms, while feature-changing rules are confined to derived forms, we can solve the duplication problem elegantly. Neither Stem Vowel Lowering nor Stem Vowel Shortening is feature-changing, and therefore both can apply freely. In addition, all kinds of redundant information can be left out of the structural description. If we compare, for example, Sommerstein's (1973) Low Vowel Rule and /ā/-Fronting (43), this simplification becomes fairly obvious. In sections 3.4 and 4.2, Metathesis of Quantity and Vowel Contraction will be discussed, allowing for even more radical rule simplifications than the ones examined above.

3.4 Metathesis of Quantity

One important prediction of the UT for Ionic-Attic outlined so far has remained implicit. The feature representations of /ā/ and /ē/ differ minimally from each other in underlying representation as well as after the application of Stem Vowel Lowering. When SVL has taken place /ā/ is specified as [-high, +low, +back], while /ɛ̄/ is specified as [-high, +low]. /ā/-Fronting (43) neutralizes this distinction, and hence we expect processes that treat the two vowels alike. Below, where we examine the recalcitrant process of Metathesis of Quantity (henceforth MQ)[10], we will show that this prediction is correct.

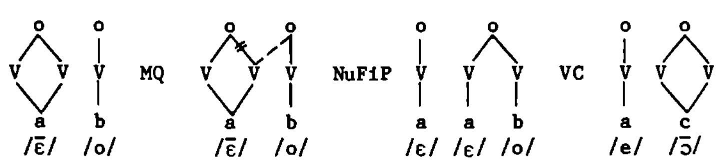
Grammont (1948:350) characterizes MQ as "un phénomène qui consiste, en ionien-attique à faire passer, en même temps qu'une voyelle longue s'abrège devant un voyelle brève, la quantité de la longue à la brève. Il s'agit là de l'application d'un sentiment d'equilibre qui a pour objet inconscient de conserver la durée totale de l'ensemble des deux voyelles" (my emphasis WdH).

Wetzels (1986:332) provides a more precise description of this phenomenon, when he states: "Because length is treated as a suprasegmental feature, MQ must be formally represented as a process of timing-point transfer. That this is exactly the right characterization of the process can be seen from [...] data, where a V̄ V̄ sequence is transformed into a V̆ V̄ sequence and where the term metathesis is therefore not applicable". Consider now the changes in the words given below:

(44)	a:	basilɛ̄wos	→	basiléɔ̄s	'king' (gen.sg.)
		khrɛ̄omay	→	khréɔ̄may (ion.)	'consult the oracle'(1.sg.pres.Med.)
		lāos	→	leɔ́s	'people'
		nāos	→	neɔ́s	'temple'
		stɛ̄atos	→	stéātos	'fat'(gen.sg.)
		phrɛ̄atos	→	phréātos	'fountain'(gen.sg.)
	b:	plɛ̄ā	→	pléā	'full' (fem.)
		thāwā	→	théā	'look'
		hermāās	→	herméɛ̄s (ion.)	proper name
		nāɔ̄n	→	neɔ́n	'temple' (gen.pl.)
		nāōs	→	neɔ́s	'temple' (acc.pl.)
		thɛ̄ɔ̄	→	théɔ̄ (ion.)	'place' (1.sg.2.aor.subj.)

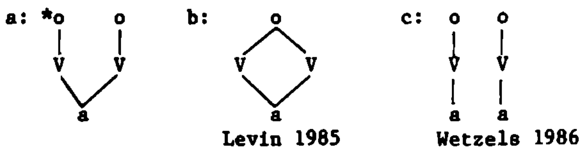
Wetzels (1986) suggests that MQ is a special type of Vowel Coalescence. In his view MQ is a retiming process in which the second vowel slot of the left syllable is resyllabified. The subsequent fusion of this slot with its tautosyllabic mate will be accomplished by coalescence. Schematically, the effects of MQ and subsequent processes are as in (45):

(45)



In (45), the Nuclear Fission Principle (NuFiP) is ordered among MQ and vowel coalescence. This principle divides an ambisyllabic vowel melody into two identical heterosyllabic short vowels. Below, we will assume that Wetzels' insightful analysis of this complex phenomenon is correct, although we will show that his formalization of MQ can undergo a radical simplification, under a theory of underspecification.

Before we go on to outline our analysis of MQ, a brief excursus on the NuFiP is in order here. In recent nonlinear phonology, rules have been proposed that create ambisyllabic long vowels. However, such structures are considered universally impossible, and two competitive resolutions for these configurations have been argued for in the literature. Levin (1985) disallows representations like (46a) in which the syllable boundary falls in the middle of the long vowel. She states that a long vowel is always dominated by one nucleus or syllable node, and as a result representation (46a) shows up as (46b). Wetzels (1986) takes a different position. He assumes that representation (46a) is input to the NuFiP, giving rise to representation (46c):

(46)


Neither solution for the ambisyllabicity problem can be ruled out on general theoretical grounds. Only empirical facts can determine whether one of the two options must be favored. In chapter 2 we discussed vowel harmony in Akan, and observed that ambisyllabic long vowels do not undergo resyllabification. Hence, it seems that ambisyllabic long vowels which arise as a by-product of vowel harmony undergo Fission. We will take this as independent evidence for the Nuclear Fission Principle.

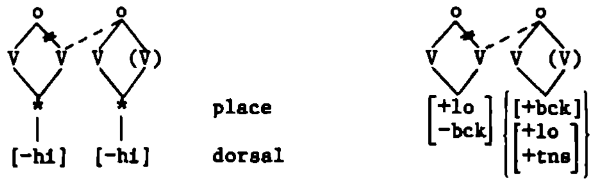
We have already noticed that MQ involves retiming, accompanied by a change in the melody. The underlying long vowel becomes redundantly [+low], and so do the lengthened mid vowels. Apparently, this change in the melody is caused by a rule of metathesis. Wetzels (1986) tries to avoid making reference to a metathesis rule by splitting MQ into three parts. MQ proper is a retiming phenomenon followed by the application of the NuFiP and the independently motivated process of vowel coalescence. Furthermore, he assumes a phonetic interpretation rule which interprets the feature specification [-back, -high] - dominated by a single V-slot - as [-low], i.e. /e/.

A closer look at the forms in (44) reveals that MQ is restricted to a subset of the vowel inventory. We can observe that the left input vowel has to be /ɛ̄/ or a fronted /ā/. The /ā/ has to be changed into [ɛ̄], since both end up as /e/. The right environment seems more complex. Whereas the vowels /o, a, ɛ̄, ā, ɔ̄/ participate in MQ, the vowel /e/ does not. The question arises why this should be so.

In the Homeric poetry we find, probably for metrical reasons, the Aeolic forms basilɛ̂es (nom.pl.) and basilɛ̂os (gen.sg.) 'king'. In Attic, the gen.sg. form appears as basiléɔ̄s, whereas the older Attic authors (e.g. Thucydides) use basilɛ̂s in the nom.pl., that is, the two vowels in hiatus have merged. This last form suggests an intermediate bisyllabic sequence to which MQ has applied. If this hypothesis is correct, we must assume that all [-high] vowels can be input to MQ.

In (47a) below, a formal representation of MQ is given which adopts from Wetzels (1986) the insight that MQ is properly defined as the retiming of a V-slot. In (47b) the formalization in Wetzels (1986) is given for comparison:

(47) a: Metathesis of Quantity b: Wetzels (1986)

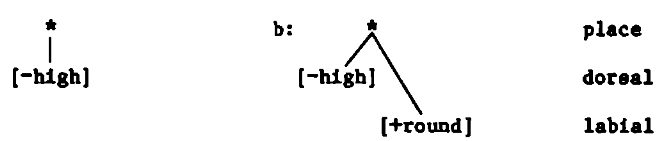


The comparison of the different statements of MQ shows that UT enables us to simplify the rule considerably.

One clarification must be added with regard to the formalization of MQ in (47a), which concerns the definition of the vowel class to which the rule is applicable. Apparently, the feature [-high] refers to the vowels /ɛ̄, (ē), ā, ɔ̄, (ō)/. We can observe, however, that vowel sequences where the left-hand vowel is /ɔ̄/ are not affected by MQ, as is shown by forms such as hḗrɔ̄os (gen sg.) and hḗrɔ̄as (acc.pl.) 'hero'. It seems that the specification [-round] or [-back] must be included in the structural description of MQ, but this is not unproblematic. Within the present UT these feature values are unspecified underlyingly, and we therefore expect them to be irrelevant at the deepest lexical levels. Since MQ is a very early lexical process, the addition of [-round] would be quite embarrassing, because this process would be the only rule that makes crucial use of this feature. Furthermore, the early assignment of [-round] would obliterate one of the basic pillars on which UT rests.

In section 1.3, we have proposed to extend the scope of Hayes' (1986a) Linking Constraint to all structure-dependent rules, including segment-internal rules which crucially refer to more than one node in the feature geometry. The phenomenon of MQ can be shown to provide evidence for this extension. If we take segment-internal association lines into account, we can appeal to the LC (96) in section 1.3 to cover the fact that /ɔ̄/ is immune to MQ. The representations of /ɛ̄/ and fronted /ā/ contain only a single segment-internal association line between the place node and the dorsal node, while /ɔ̄/ contains one association line between the place node and the dorsal node and another between the place node and the labial node, as shown in (48):

(48) a: b:



By interpreting MQ (47a) as a rule which can apply to representations containing only one association line, the LC explains why the [-high] vowels /ɛ̄/ and /ā/, i.e. with /ɔ̄/ excluded, form a natural class for MQ. But now consider those cases where the right-hand vowel is

[+round]. In these forms MQ applies freely, irrespective of the fact that the place node is multiple-branching. Hence, the data in (44) suggest that mismatches of the association lines in the context of a P-rule, rather than in the focus, do not block its application.

Schein and Steriade (1986:712) observe one important characteristic of geminates: "geminates are never restricted from participating in rules that do not affect their segmental make-up". They discuss, for example, structure-dependent rounding assimilation rules in Tigrinya. One rule applies to geminate and nongeminate glides alike. This rounding rule differs from other rules in that it does not change the matrix of the participating glide. The mid vowel /ä/ undergoes optional rounding to /å/ before /w/, whereas rounding is obligatory when /ä/ and /w/ are tautosyllabic:

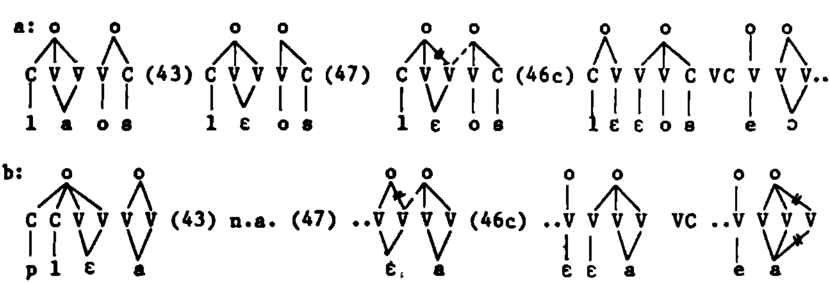
(49) a: /ṣäwär-a/ → ṣåwära ~ ṣäwära 'carry'(perf.3.sg.masc.)
/ṣäwir-u/ → ṣåwiru ~ ṣäwiru 'carry'(gerund.3.sg.masc.)
b: /yə-fəttäw/ → yəfəttåw 'love'(refl.imperf.3.sg.masc.)
/yä-wləd/ → yåwləd 'engender'(caus.iuss.3.sg.masc.)
c: /zäwwär-a/ → zåwwära 'turn'(perf.3.sg.masc.)
/säwwəe/ → såwwəɛe 'call'(perf.3.sg.masc.)

The Tigrinya facts show that the free application of MQ to forms like /basilɛ̄(w)os/ and /thɛ̄ɔ̄/ is not an idiosyncrasy of the rule itself, but represents a more general property of multiple-branching nodes constituting the context of a particular phonological rule.

Schein and Steriade solve the issue of contextual inalterability by confining their Uniform Applicability Condition to nodes really affected by the rule. A slightly weakened version of Hayes' Linking Constraint obtains the same results. Consider (50):

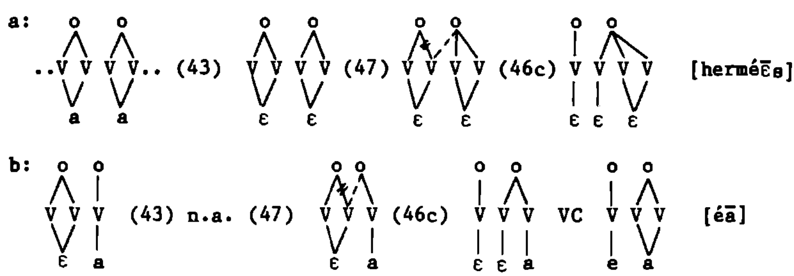
(50) Linking Constraint (alternative)
Association lines mentioned in the focus of a rule are interpreted as exhaustive.

Hence, the formalization of MQ with the feature [-high] can be maintained only if we adopt the extended and slightly weakened version of Hayes' (1986a) Linking Constraint, and assume that the output of MQ must undergo additional changes produced by resyllabification (e.g. hermɛ́ɛ̄s → hermɛ̂s) and vowel coalescence (e.g. lɛ̄os → lɛ.ɛos → leɔ́s). (51) contains some sample derivations illustrating both MQ and subsequent changes:

(51)


These derivations show that MQ is crucially ordered after /ā/-Fronting (43), since otherwise we would wrongly predict *laɔ̄́s next to pléā. Recall, however, that we have argued in the preceding section that /ā/-Fronting is ordered after vowel coalescence. Apparently, we are faced with an ordering paradox. In the next chapter, we will return to this issue in some detail, and it will turn out that vowel contraction is the result of two separate rules, viz. Leftward Spreading, which turns e+V sequences into a long vowel, and Vowel Coalescence proper. If we assume that MQ is ordered after Leftward Spreading and /ā/-Fronting, but before Vowel Coalescence proper, we can account for all the facts.

There exists some independent confirmation for these ordering relations. Wetzels (1986) notes that the Ionic form [éā] 'I was', which is attested in Homer and derived from underlying /ɛ̄a/, constitutes a problem for his analysis of MQ. In the Ionic dialect, the sequence e+a either remains uncontracted or is contracted into [ɛ̄]. Hence, if MQ is a special type of coalescence, the form *éɛ̄ is expected. We will show that the attested form éā is perfectly regular, even in the Ionic dialect, on the assumption that MQ applies after the application of Leftward Spreading and /ā/-Fronting.[11] Within the present analysis, the difference between the Ionic forms herméɛ̄s and éā can be reduced to a distinction due to the application versus nonapplication of /ā/-Fronting: at the stage of the derivation where /ā/-Fronting applies, [+back] is still dominated by a single V-slot in the latter case:

(52)


To summarize we propose to typify MQ as a retiming phenomenon, following Wetzels (1986). We have shown that the output of MQ may be input to several independently motivated processes of which vowel coalescence is the most important. Even the Ionic form éā can be accounted for if it is assumed that /ā/-Fronting applies before MQ.

Footnotes

1: In the fifth century B.C. *$\overline{ae}$ and *ē are still distinct in the Ionic dialects of Amorgos, Naxos and Ceos. In these dialects *$\overline{ae}$ was represented by the grapheme H, while the vowel *ē was spelled E. After the fifth century both are represented by H, which indicates that the distinction became neutralized.

2: The SPE features 'high, low, back, round' are most appropriate for the description of a system containing five short and five long vowels. However, since only three vowel heights can be distinguished, the feature [back] must be used to distinguish /ε̄/ and /ā/, and [round] to distinguish /ɔ̄/ and /ā/ in vowel systems such as that of Ionic-Attic. Several scholars (e.g. Kiparsky 1968, Ladefoged 1971, Aitchison 1976, Bichakjian 1986) have drawn attention to the problem of distinguishing four heights within the SPE system. For example, Aitchison (1976) introduces the feature [mid] next to [high] and [low] to characterize the four-grade system of Ancient Greek. In recent publications concerning feature specification (cf. Kaye et al. 1985) the feature [Advanced Tongue Root] is introduced to distinguish between the closed mid vowels /e, o/ and the open mid vowels /ε, ɔ/. We assume that this feature is also responsible for the distinction between /ē, ō/ and /ε̄, ɔ̄/ in Early Ionic-Attic.

3: If it turned out that the fronting of /u, ū/ to [ü, ǖ] took place as early as the seventh century we would have to add the low-level redundancy rule (i) to the grammar of Attic. This rule would specify all high vowels as [-back]:

(i) [+high] → [-back]

4: From a diachronic perspective, the forms in (15) are perfectly regular, since they were consonant-initial at an earlier stage of Greek. A form like ȇkhon goes back to *ésekhon, while ērgazdómε̄n stems from *ewergazdomε̄n. The presence of /s/ or /w/ blocked the merger of the stem vowel and the augment into /ε̄/. After the loss of intervocalic /s/ and /w/ the sequence e+e was changed into /ē/. This change is similar to e+e contraction in forms such as philȇte (←philé+e+te).

5: The claim that the augment is added to the verbal stem on level 1 seems problematic if we take into consideration the accentuation of augmented verbs. With respect to the accent rules the augment behaves as a preverbial clitic which blocks the assignment of accent to any syllable to its left. For example, for the form par-é-skhon 'provide with' we wrongly expect *páreskhon (cf. pár-ε̄may 'staying'). We do not have a solution for this property of the augment. However, we would like to emphasize that the accentuation of augmented verbs is problematic in any account.

6: This is not to say that deverbal nouns in which the weak verbal form shows up do not exist (cf. tribε̄́ 'wastage', lipotaksíā 'desertion', phugε̄́ 'escape'). However, they are clearly a minority.

7: In general, words which end in a short vowel and words which end in a VC sequence behave alike for the rules of accentuation, i.e. they count as light syllables. The situation is more complex in forms ending in the diphthongs /ay, oy, ey/. In the optative, they count as bimoric (e.g. lū́oy (3.sg.pres.), lūóytε̄n (3.du.pres.) vs. lūóyte (2.pl.pres.) and lūȇ (2.sg.pres. imp.) 'loose'). However, in most other tenses, these diphthongs count as monomoric (e.g. lūómay (1.sg.pres.ind.Med.)). In the nominative plural, the diphthongs /ay, oy/ count as monomoric, as can be deduced from the following alternations: khɔ̄́rā (nom.sg.) vs. khɔ̄̂ray (nom.pl.) 'land', thálatta (nom.sg.), thálattay (nom.pl.) vs. thaláttε̄s (gen.sg.) 'sea' and nε̂sos (nom.sg.), nε̂soy (nom.pl.) vs. nέsō̄ (gen.sg.) 'island'. We will not go into the problem of determining the moraic status of the diphthongs here, since it is irrelevant for our purposes.

8: In the optative, the quality of the theme vowel cannot be predicted in a similar fashion. It shows up as /o/ (e.g. lúoyte, lúsoyte etc.). We will assume that the vowel quality for the optative is specified in underlying representation.

9: Before a nasal, regressive nasalization of a labial or velar stop occurs. Some examples appear in (ii):

(ii)	léypɔ̄	léleymmay	'leave'
	graphɔ̄	gégrammay	'write'
	phulakέ 'custody'	pephúlaŋmay	'guard'

10: MQ is limited to the Ionic-Attic dialects. The Attic forms neɔ́s 'ship' (gen.sg.), 'temple' (nom.sg.) are still nāós in Doric. For a discussion of this phenomenon cf. Schwyzer (1939:245-246), Lejeune (1972:253-257), Grammont (1948:350-352), Ruijgh (1968), Sommerstein (1973:69-70) and Wetzels (1986:331-335).

11: Recall that in Ionic /ā/ is fronted to [ε̄] in all cases, since in this dialect the segments [r, i, e] do not act as blockers.

4.0 Introduction

This chapter deals with the formal description of vowel coalescence (henceforth VC) in Attic. Second, it is intended to provide support for the general concept of vowel coalescence developed in chapter 2. A detailed survey of the VC data will be presented in section 4.1. Next, it will be shown that VC must be split into two rules which have different properties, and which apply at different levels in the lexical component. Furthermore, we will examine the phenomenon of Compensatory Lengthening (henceforth CL) which also has the property of applying more than once, and under different conditions. The formal description of VC will make up the main part of section 4.3. We will propose to treat VC as a resyllabification phenomenon which causes the merger of nondistict feature matrices. It will turn out that only one VC rule has to be posited, and that some contractions which have been explained by previous scholars as the result of one and the same VC process, are better accounted for by a separate rule of Leftward Spreading, which has independent motivation. Finally, we will discuss the behavior of the high vowels /i, u/ in hiatus. These vowels do not participate in VC proper.[1] If a high vowel forms the left-hand environment of VC neither resyllabification nor fusion takes place. If, on the other hand, a high vowel constitutes the right-hand environment, resyllabification results in a diphthong. It will be shown that VC does not need to be restricted to nonhigh vowels in the structural description of the VC rule, since this can be derived from independently motivated processes, and from the general format of vowel coalescence.

4.1 Vowel Coalescence: the data and its characteristics

At several stages in the history of Ancient Greek processes arose that resulted in vocalic hiatus. In chapter 2, we noticed that vowel hiatus can be regarded as a sonority clash, because vowels are the most sonorous elements in the syllable. We claimed that such a situation is highly marked, and if a succession of two or more vowels arises by means of morphological concatenation or the application of phonological rules, processes will be activated to eliminate this sonority clash. We presented a variety of options which present themselves in human languages. In this chapter we will examine vowel coalescence in the Attic dialect of Ancient Greek. Two subtypes are traditionally distinguished: word-internal Vowel Contraction (e.g. géne-a → génε̄ 'race' nom.acc.pl.), and word-external Crasis (e.g. pro+érgō 'ahead in work' → prṓrgō 'helpful' and to enantion → tōnántion 'the opposite'). These rules, determining quantity and quality of the output vowel, are similar in many respects.[2] For this reason, it seems likely that the principles governing Vowel Contraction and Crasis are the same. We will restrict ourselves to word-internal contraction, unless the word-external contractions bring to light properties which cannot be highlighted word-internally.

The Ancient Greek dialects are quite diverse as far as vowel coalescence is concerned. The phenomenon manifests itself most clearly in Attic, and this is why we will focus on this dialect, which is in any case the most studied and best documented dialect of Ancient Greek. Below, a survey of the relevant coalescence data is presented:[3]

(1) a:	e+a	= ε̄	gene-a	→ génε̄	'race'	(nom.acc.pl.)
	e+a	= ā	khree-a	→ khréā	'debt'	
	e+e	= ē	phile-ete	→ philē̂te	'love'	(2.pl.pres.ind.)
	e+o	= ō	phile-omen	→ philō̂men		(1.pl.pres.ind.)
	e+ε̄	= ε̄	phile-ε̄te	→ philε̄̂te		(2.pl.pres.subj.)
	e+ɔ̄	= ɔ̄	phile-ɔ̄men	→ philɔ̄̂men		(1.pl.pres.subj.)
	e+i	= ey	gene-i	→ géney	'race'	(dat.sg.)
	e+ey	= ey	phile-ey	→ philêy	'love'	(3.sg.pres.ind.)
	e+oy	= oy	phile-oyte	→ philôyte		(2.pl.pres.opt.)
b:	a+a	= ā	gera-a	→ gérā	'prize, privilige'	
	a+e	= ā	tīma-ete	→ tīmā̂te	'honor'	
	a+o	= ɔ̄	tīma-omen	→ tīmɔ̄̂men		
	a+ε̄	= ā	tīma-ε̄te	→ tīmā̂te		
	a+ɔ̄	= ɔ̄	tīma-ɔ̄men	→ tīmɔ̄̂men		
	a+y	= ay	gera-i	→ géray	'privilege, prize'	(dat.sg.)
	a+ey	= āy	tīma-ey	→ tīmā̂y		
	a+oy	= ɔ̄y	tīma-oyte	→ tīmɔ̄̂yte		
c:	o+a	= ɔ̄	aydo-a	→ aydɔ̄̂	'shame'	(acc.sg.)
	o+e	= ō	dε̄lo-ete	→ dε̄lō̂te	'manifest'	
	o+o	= ō	dε̄lo-omen	→ dε̄lō̂men		
	o+ε̄	= ε̄	dε̄lo-ε̄te	→ dε̄lɔ̄̂te		
	o+ɔ̄	= ɔ̄	dε̄lo-ɔ̄men	→ dε̄lɔ̄̂men		
	o+y	= oy	aydo-i	→ aydôy	'shame'	(dat.sg.)
	o+ey	= oy	dε̄lo-ey	→ dε̄lôy		
	o+oy	= oy	dε̄lo-oyte	→ dε̄lôyte		
d:	ā+y	= āy	grā-idion	→ grā́ydion[4]	'old woman'	
e:	ε̄+e	= ε̄	zdε̄-ete	→ zdε̄̂te	'live'	
	ε̄+o	= ɔ̄	zdε̄-omen	→ zdɔ̄̂men		
	ε̄+ε̄	= ε̄	zdε̄-ε̄te	→ zdε̄̂te		
	ε̄+ɔ̄	= ɔ̄	zdε̄-ɔ̄men	→ zdɔ̄̂men		
	ε̄+i	= ε̄y	klε̄-ithron	→ klε̄̂ythron	'lock'	
f:	ɔ̄+e	= ɔ̄	rhīgɔ̄-ete	→ rhīgɔ̄̂te	'freeze'	
	ɔ̄+o	= ɔ̄	rhīgɔ̄-omen	→ rhīgɔ̄̂men		
	ɔ̄+ε̄	= ɔ̄	rhīgɔ̄-ε̄te	→ rhīgɔ̄̂te		
	ɔ̄+ɔ̄	= ɔ̄	rhīgɔ̄-ɔ̄men	→ rhīgɔ̄̂men		
	ɔ̄+i	= ɔ̄y	hε̄rɔ̄-i	→ hε̄́rɔ̄y	'hero'	

The data in (1) reveal the most important properties of VC. Sommerstein (1973:55) gives the following informal characterization:

(2) a. The output vowel is always long
    b. The output vowel is round if and only if at least one of the input vowels is round

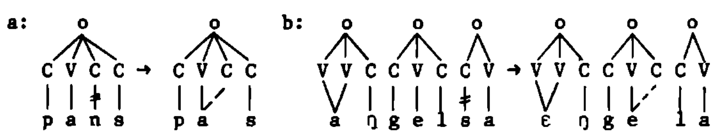
c. The output vowel is low if and only if at least one of the input vowels is low

d. The output vowel is back if it is round, or if the first of the input vowels is back and not otherwise

However, the observations stated in (2) do not exhaustively describe the VC process. If one of the input vowels is [+high] VC proper does not take place; if the right-hand input vowel is [+high] and the left-hand vowel is nonhigh, merger into a diphthong occurs; finally, if the left input vowel is high, the vowels in hiatus remain heterosyllabic and a transitional, homorganic glide is inserted to resolve the hiatus (e.g. dí^{y}odos 'passage', kú^{w}amos 'bean'). This peculiar behavior of high vowels in hiatus will receive extensive discussion in section 4.4.

A closer look at (1) shows that some vowel sequences do not constitute an input for VC. These sequences all involve the class of closed mid vowels /ē,ō/. Given the UT outlined in the previous chapter, this gap is not at all surprising, since all underlying mid vowels become [+low] by Stem Vowel Lowering. The vowels [ē,ō] only appear in derived environments as a result of vowel coalescence or compensatory lengthening. We will examine the extent to which these secondary mid vowels can trigger contraction.

CL takes place in VC_1C_2 sequences, in which the loss of one consonant is accompanied by the lengthening of the vowel. Two possibilities arise, viz. the loss of C_1 and lengthening of the vowel, or the loss of C_2 with subsequent retiming of C_1 to the vacated C-slot and lengthening of the vowel. They are illustrated in (3):

(3) 

(pā̂s vs. pantós 'all') (ɛ́ŋgēla 'anounce' vs. élūsa 'loose' aor.)

The output of CL is a possible trigger of VC when a vowel precedes the VCC cluster, as is shown in (4):

(4) a:	tīma-onsa	→ tīma-ōsa	→ tīmɔ̂sa	'honor' (pres.part.)
	phile-onsa	→ phile-ōsa	→ philō̂sa	'love'
	dɛ̄lo-onsa	→ dɛ̄lo-ōsa	→ dɛ̄lō̂sa	'manifest'
b:	tīma-e-en	→ tīma-ēn	→ tīmâ̄n	(pres.infin.)
	phile-e-en	→ phile-ēn	→ philē̂n	
	dɛ̄lo-e-en	→ dɛ̄lo-ēn	→ dɛ̄lō̂n	

However, there is no evidence that CL must be ordered before VC. The same results can be obtained under the opposite ordering, e.g. tīma-onsa → tīmɔ̄nsa → tīmɔ̂sa. Furthermore, in (4b) VC arbitrarily applies from right to left. Alternatively, it is possible to assume that the three short vowels in hiatus are contracted in one swoop. Hence, the closed mid vowels in (4) do not in any respect behave differently from their short counterparts /e,o/ and consequently we do not have to treat them separately.

If we go through the generalizations in (2) once again, they appear to fall into two groups. Generalization (2a) concerns the quantitative aspect, while the remaining ones concern its qualitative aspect. The observation that VC affects the segmental make-up of the vowels in hiatus without affecting the suprasegmental properties of the sequence as a whole, suggests a nonlinear approach, since in this framework the segmental and suprasegmental properties are arrayed on independent planes (cf. chapter 2).

The statements in (2b-d) imply that both input vowels contribute to the quality of the output. For example, in case of o+ɛ̄ contraction the output retains the features [+round, +back] from the left-hand input vowel, and [+low] from the right-hand one. We thus may regard the output of VC as an articulatory compromise of the segmental content of the input vowels. Thus, the phenomenon of VC in Attic seems to support the hypothesis outlined in chapter 2.

Both Sommerstein (1973) and Wetzels (1986) provide a formal account of VC in Classical Attic without paying much attention to the problematic cases. Sommerstein notes the existence of several exceptions, such as the pair [néos] 'new' where VC fails to apply and [nōmɛ̄níā] 'new moon', which apparently has undergone VC. Ruijgh (1976) adds a set of problematic data to this pair, cf. (5):

(5) a: néos 'new', theós 'god'
  b: boós 'ox', grāós 'old woman' (gen.sg.)
  c: glukéos (gen.sg.masc.), glukéa (nom.pl.ntr.) 'sweet'
  d: póleɔ̄s 'city', hippéɔ̄s 'horseman' (gen.sg.)
  e: endewea → endeâ 'lacking', hugiea → hugiâ 'healthy' (acc.sg.)
  f: khalkea → khalkâ 'cupper', ostea → ostâ 'bone' (nom.pl.neut.)
  g: nawtāo → náwtō 'sailor', tamiāo → tamíō 'steward' (gen.sg.)
  h: alɛ̄theas → alɛ̄thês 'true', triɛ̄reas → triɛ́rēs 'trireme'(acc.pl.)

Most of the forms in (5) will be referred to in passing in the next sections, and receive full attention in section 4.3.

Let us, finally, take a closer look at statement (2d) which is of a different kind than those in (2b-c). Essentially, (2d) expresses the fact that the feature [back] is redundant if one of the input vowels is specified as [+round]. Additionally, it states that elsewhere the output vowel may become [+back] if and only if the left-hand vowel is marked as such. More specifically, the second part of (2d) expresses the difference between e+a and a+e coalescence: the former generally results in [ɛ̄], and the latter always in [ā].

Sommerstein (1973) is forced to formalize VC as a directional assimilation process, because of the asymmetrical behavior of the feature [back]. In (6) below, Sommerstein's formal description of VC (and Truncation) is given, followed by an illustration of the effects of these rules:

(6) a: Contraction I

$$\begin{bmatrix} V \\ -high \end{bmatrix} \rightarrow \begin{bmatrix} +long \\ \left\langle \left\{ \begin{matrix} [\alpha low] \\ \begin{bmatrix} \beta round \\ \langle \gamma back \rangle \end{bmatrix} \end{matrix} \right\}_1 \right\rangle \end{bmatrix}_1 \Big/ \begin{bmatrix} \begin{bmatrix} V \\ -high \\ -long \end{bmatrix} \\ \left\langle \left\{ \begin{matrix} [\alpha low] \\ \begin{bmatrix} \beta round \\ \langle \gamma back \rangle \end{bmatrix} \end{matrix} \right\}_1 \right\rangle \end{bmatrix}_1 \quad \begin{bmatrix} \left\{ \begin{matrix} \overline{[-low]} \\ \begin{bmatrix} -round \\ \langle -back \rangle \end{bmatrix} \end{matrix} \right\}_1 \end{bmatrix}_1$$

b: Contraction II (Truncation)

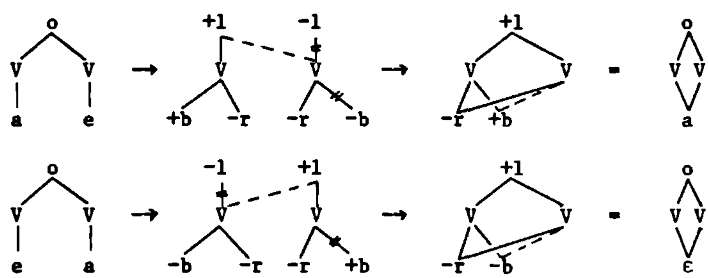
$$\begin{bmatrix} V \\ -long \\ -high \end{bmatrix} \rightarrow \emptyset \;/\; \text{---} \begin{bmatrix} V \\ -high \end{bmatrix}$$

(7) e+e → e ē → ∅ ē   e+o → e ō → ∅ ō
o+e → o ō → ∅ ō   o+a → o ɔ̄ → ∅ ɔ̄
a+e → a ā → ∅ ā   a+o → a ɔ̄ → ∅ ɔ̄
e+a → e ɛ̄ → ∅ ɛ̄

In the nonlinear account proposed by Wetzels (1986), the difference between e+a and a+e coalescence is also considered to be a property of VC. He suggests that VC is an autosegmental spreading process within the domain of the syllable nucleus. He assumes that the features [+round] and [+low] receive autosegmental status, and spread to their nonround and nonlow tautosyllabic mates. Furthermore, he posits a rule deleting the feature [back] if a tautosyllabic vowel precedes. As a consequence the feature [-back] spreads from left to right in case of e+a contraction, while [+back] spreads in case of a+e contraction. The following derivations show how the mechanisms he proposes work:

(8) a:

b:



Again, VC is treated as a phenomenon that consists of several components: an autosegmental spreading component and a deletion component. In addition, Wetzels posits a postlexical redundancy rule that specifies all round vowels as [+back], which repairs the ill effects of backness deletion in cases such as e+o contraction. The vowel coalescence rule generates /ø̄/, which has to be changed into its back counterpart [ō].

Both in Sommerstein's (1973) linear account and in Wetzels' (1986) nonlinear account, VC is divided into several rules, which makes it seem as if VC belonged to a class of highly marked phonological processes. We could also conclude that the nature of this phenomenon is not yet fully understood. The main reason for the complex nature of these analyses is that both Sommerstein and Wetzels want to incorporate the difference between e+a and a+e contraction in the structural description of VC. The important question is whether this is the right strategy. We will argue that independent reasons exist that account for this difference.

In section 3.3.3.3 we examined the phenomenon of /ā/-Fronting, under the influence of which /ā/ becomes [ɛ̄]. If we assume that the output of e+a contraction undergoes fronting, while the output of a+e contraction is exempted from undergoing this rule, we do not have to include the asymmetrical behavior of the feature [back] in the rule of VC. Such an account suggests that /ā/-Fronting is ordered between e+a contraction and a+e contraction, which by implication must be considered two different processes. In the next section, we will argue that there are good reasons to believe that this suggestion is correct. More specifically, we will argue that e+V contractions result from a phenomenon that we will call Leftward Spreading, while all remaining contractions are instances of genuine Vowel Coalescence.

4.2 Marked versus unmarked rules

Ideally, any single phonological change is accomplished by the application of a single P-rule. In this section, we will discuss vowel coalescence and compensatory lengthening in Attic. Superficially, the coalescence data as well as the compensatory lengthening data seem to be derived by a single rule of VC and a single rule of CL. We will present evidence that this hypothesis leads to unwanted types of rule telescoping. In particular, we will show that two independently motivated processes: /ā/-Fronting and w-Deletion, and one rule-specific condition: the Bisyllabicity Condition, lend support to the claim that the resolution of vowel hiatus is the result of two separate processes.

4.2.1 Leftward Spreading and Vowel Coalescence

The first rule we want to discuss in favor of two rules of vowel coalescence is the by now familiar /ā/-Fronting. The forms in (9) below show that the output of e+a coalescence undergo this fronting rule, while the output of a+e coalescence do not:

(9) a:	gene-a	→	génɛ̄	'race'
	saphe-a	→	saphɛ̂	'clear'
	periklee-a	→	perikléā	proper name
	hugie-a	→	hugiâ	'healthy'
b:	tīma-ete	→	tīmâte	'honor'
	spa-ete	→	spâte	'tear'
	ania-ete	→	aniâte	'tease'

If e+a and a+e are contracted into a long vowel by the same rule, we expect forms such as *tīmɛ̂te and *spɛ̂te to be grammatical. We can account for the non-application of /ā/-Fronting to the output of a+e coalescence, if we assume that two different processes are responsible for the two types of vowel merger in (9).

The second argument in favor of two rules of vowel coalescence can be derived from w-Deletion. In Attic the labial glide almost always disappears, except when it constitutes the second half of a diphthong.

w-Deletion gives rise to the following alternations:

(10) a:	nom.sg.	gen.sg.	
	basiléw-s	basilé-ɔ̄s	'king'
	gonéw-s	goné-ɔ̄s	'parent'
	hieréw-s	hieré-ɔ̄s	'priest'
b:	pléɔ̄ (pres.ind.)	péplewka (perf.ind.)	'sail'
	pnéɔ̄	pépnewka	'blow'
	rhéɔ̄	rhuɛ́somay (fut.ind.Med.)	'flow'

The forms in (10) show that an intervocalic /w/ acts as a blocker for vowel coalescence, if the left-hand vowel is /e/. However, there are some problematic cases where an underlying /w/ apparently does not have this blocking effect. Within the paradigm of one form both contracted and uncontracted vowel sequences occur side by side, irrespective of an intervening /w/. Some verbal forms are given in (11):

(11)	pléomen	rhéomen	néomen	(1.pl.pres.ind.)
	pléɔ̄si	rhéɔ̄si	néɔ̄si	(3.pl.pres.ind.)
	plē̂te	rhē̂te	nē̂te	(2.pl.pres.ind.)
	plē̂n	rhē̂n	nē̂n	(pres.ind.)
	péplewka	rhuɛ́somay	énewsa	
	'sail'	'flow'	'swim'	

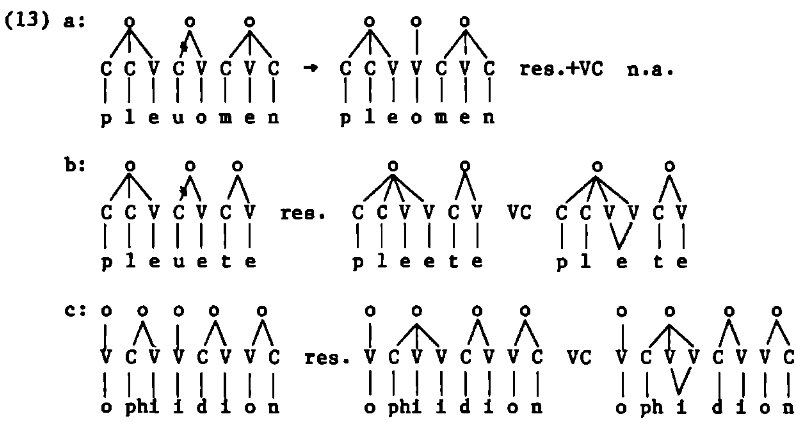
One look at the paradigms above reveals that fusion takes place if the two vowels in hiatus are identical. Hence, the generalization seems to be that an intervening /w/ prevents vowel coalescence of e+V into a single long vowel, if V is not /e/. It will turn out that identity is indeed the important factor in this type of vowel fusion.

In section 4.1 it was observed that VC applies to nonhigh vowels only. The data in (12a) seem to contradict this observation, since two identical high vowels merge into a long high vowel. Furthermore, the 3.pl.pres.ind. forms generally remain unaffected by VC. Nevertheless, VC takes place in a number of cases as is shown in (12b):

(12) a:	di-īphilos	→ dī́philos	'dear to Zeus'	
	ophi-idion	→ ophī́dion	'little snake'	
	di-ekhɔ̄	→ diékhɔ̄	'go through'	
b:	hista-āsi	→ histā̂si	'set'	(vs. histamen)
	tithe-āsi	→ tithéāsi	'place'	
	dido-āsi	→ didóāsi	'give'	

The data in (12) repeat the pattern already observed in (11): two identical vowels in hiatus merge, while the hiatus remains stable in cases where the vowels are distinct. Lejeune (1972:259) observes that "la fréquence des contractions est plus grande entre voyelles de même timbre qu'entre voyelles de timbres différents". He accounts for the strong tendency of identical vowels to merge in the following way: "Lorsque les deux voyelles avaient le même timbre, il a suffi de la suppression du ressaut d'energie expiratoire qui les maintenait distinctes pour qu'elles se fondent en une voyelle longue, de même timbre que ses éléments constituants" (p.258). Let us try to translate this phonetic explanation into phonological terms.

Below in section 4.3, where we will provide a detailed discussion of vowel coalescence proper, it will be argued that the tendency for vowels to contract is related to phonological distinctness. Nondistinct vowels exhibit a strong inclination to merge, while distinct vowels never do. The notion of distinctness must not be misunderstood, however. At the surface, the vowels /o/ and /a/ are distinct, but in underlying representation they are not, given the theory of underspecification advocated in the present study. We will show that one of the major characteristics of vowel coalescence is related to structure-preservation: all prespecified feature values survive the process of coalescence. If this claim is correct, there is no need for a feature-changing mechanism. Consequently, we can restrict VC to nondistinct vowels. It will turn out in section 4.3.2 that at the stage in the derivation where VC takes place, all sequences of the type e+V, where V is not /e/, are distinct. Therefore, in (11) and (12) only a string of identical vowels fulfills the structural requirements of VC proper. Some sample derivations are given in (13):[5]



On the other hand, if we took for granted that all instances of vowel merger are the result of one general rule of vowel coalescence, it would be difficult to understand why an underlying /w/ blocks the fusion of different vowels, while it does not prevent the fusion of identical vowels. We therefore take the different reflexes of the forms in (10) and (11) (with respect to /w/-Deletion) as a second indication that actually two rules are responsible for the resolution of vocalic hiatus.

The third argument for the claim that vowel merger is the result of two separate processes can be inferred from the so-called Bisyllabicity Condition, which disfavors vowel contraction in bisyllabic words. Schwyzer (1939:251) notices that "Silbenzuwachs des Wortes fördert die Kontraktion von eo, eō, ea aus ejo, eso...usw. im Ionisch-Attischen, während Zweisilbigkeit bzw. die freilich nicht konsequente Vermeidung von Einsilbigkeit sie hindert." One striking fact in Schwyzer's statement is that his examples all involve the mid vowel /e/ as their left input vowel. The examples in (14) show why we must mention /e/ explicitly, as only the e+V forms are subject to the Bisyllabicity Condition, while the remaining forms are not:

(14) a:	theós	'god'	(cf. thômantis proper name)
	déɔ̄	'bind'	(cf. dômen 1.pl.pres.ind.)
	néos	'new'	(cf. nōmēníā 'new moon')
	éar	'spring'	(cf. ε̂ros gen.sg.)
b:	draeys → drâys	'do' (2.sg.pres.ind.)	
	zdε̄eys → zdε̂ys	'live' (id.)	
	rhoɔ̄n → rhɔ̂n	'stream' (gen.pl.)	

The facts above divide the potential contraction data into two types: the e+V type, in which fusion is blocked if the input word is bisyllabic, and the elsewhere type, in which fusion takes place without taking notice of the length of the input word.

Summarizing, a number of properties distinguishes the coalescence of e+V sequences from all other sequences. The output of e+a contraction undergoes /ā/-Fronting, whereas the output of a+e contraction does not. Secondly, an intervening /w/ blocks e+V contraction if the second vowel is not /e/, but not when this vowel is /e/. Finally, the former type of vowel coalescence is constrained by the Bisyllabicity Condition, whereas all other sequences merge freely. The important question is why an /e/ in prevocalic position consistently behaves differently with respect to vowel merger. Given the theory of underspecification advanced here, the asymmetrical behavior of /e/ becomes intelligible, since it is, as we will argue, the default vowel.

By positing a rule of Leftward Spreading, which spreads the segmental make-up of the right-hand vowel to a melodically unspecified V-slot to its left and a genuine Vowel Coalescence rule, which takes the remaining sequences as its input, we can account for the differences observed quite nicely. Furthermore, we have a principled explanation for the fact why sequences of e+V behave consistently differently from sequences a+V, o+V..etcetera.

An apparent disadvantage of our hypothesis seems to be that we are forced to posit two distinct processes to account for the contraction facts of Attic, instead of one general VC rule. However, in the remainder of this section we will argue that the rule of Leftward Spreading does not add to the complexity of the grammar, since the rule is independently necessary.

In section 3.3.2 we examined the word-formation processes of Augmentation and Perfect Reduplication. These prefixation rules consist of two parts: the first is a morphological operation which adds an empty timing slot to a verb stem, and the second is a phonological spreading operation which spreads the melody of a stem-initial slot onto the added prefix, as illustrated in (15):

```
(15) a: -V C-     Pref. V -V C- V C        Spr. V  V C V C    [ε̂gon]
         | |               | |  | |              `\| | | |
         a g               a g  o n                a g o n

     b: -C C V C- Pref. C V -C C V C- C V Spr. C V C C V C C V [péplewka]
         | | | |             | | | |  | |          `\| | | | | |
         p l e u             p l e u  k a            p l e u k a
```

The fact that the formal statement of both Augmentation (12) and Perfect Reduplication (17) mentions the same spreading operation leads to redundancy in the system and shows that we are missing a generalization. By postulating an independent phonological spreading rule, viz. Leftward Spreading (16), we can simplify the statements of the prefixation rules and eliminate the redundancy from the grammar. Furthermore, we do not need to posit rules that accomplish morphological and phonological changes at the same time. Consequently, Augmentation and Perfect Reduplication will in no respect deviate from the normal word-formation processes.

```
(16) Leftward Spreading: (LS)
       X  X
        `\|
         [-]
```

If LS already is a rule in the grammar of Attic, the e+V contractions can be derived similar to Augmentation and Perfect Reduplication, since /e/ is indistinguishable from the timing slots inserted through prefixation. Hence, the claim that e+V must be treated differently does not add any complexity to the grammar, since LS must be assumed in any analysis. Some sample derivations are given below:

```
(17) a: /gene-a/ → [génε̄]  'race'
        C V C V - V   LS  C V C V  V   /ā/-Fr  C V C V V
        | | |     |       | | |  `\|           | | |  V
        g e n    +l       g e n   +l           g e n  ε
                 +b               +b

     b: /hugie-a/ → [hugiâ] 'healthy'
        C V C V V - V  LS  C V C V V  V  /ā/-Fr  n.a.
        | | | |     |      | | | |  `\|
        h u g i    +l      h u g i   +l
                   +b                +b

     c: /phile-omen/ → philômen] 'love'
        C  V C V - V C V C  LS  C  V C V  V C V C
        |  | |     | | | |      |  | |  `\| | | |
        ph i l    +r m e n      ph i l   +r m e n
```

If we let LS handle the augmentation and the e+V data, we predict that the conditions under which spreading occurs are the same. This prediction seems to be borne out by the facts, although we cannot always verify it directly.

First, the derivations in (15a) and (17a) show that both /ā/s resulting from augmentation and from e+V contraction undergo /ā/-Fronting as expected. However, the effect of the Bisyllabicity Condition cannot be verified, since the secondary tenses in the indicative are always trisyllabic or longer. Finally, the blocking effect of an intervocalic /w/ is also hard to test synchronically, since word-initial /w/s do not occur. If we take into consideration the historical development of vowel-initial verbs that originate from /w/-initial ones, we observe that the verbs in (18a) take the syllabic augment which does not merge with the stem vowel, while in the /e/-initial verbs in (18b) the augment and stem vowel are merged into a long [ē]:

(18)	Proto-Attic		Attic		
a:	walískomay	>	halískomay	: heálɔ̄ka, heā́lɔ̄n	'be captured'
	-wáŋnūmi	>	-áŋnūmi	: -éākea, -eágɛ̄n	'break'
b:	wethízdɔ̄	>	ethízdɔ̄	: ḗthisa, ḗthika	'accustom'
	welítssɔ̄	>	helíttɔ̄	: hḗliksa, hḗliŋmay	'roll'

Hence, from a diachronic point of view, the forms in (18) are subject to the same conditions as the forms in (11). The *w blocks the merger of the augment and the stem vowel, just in case they are distinct. If the stem vowel is /e/, merger applies freely. In section 3.3.2, we suggested two possible synchronic analyses for data such as those in (18). The first is an abstract analysis in which it is arbitrarily assumed that verbs like (18) begin with /w/. The second option is that the verbs in (18a) are lexically marked with the diacritic rule feature [-resyllabification], and those in (18b) with the rule feature [-SVL]. In the abstract analysis, the account of the forms in (18) runs in the same way as the account of the data in (11). The underlying /w/ blocks LS, whereas it does not block resyllabification and Vowel Coalescence of nondistinct vowels. The assumption of an abstract /w/ thus proves to be insightful, since it enables us to explain the striking similarity between the forms in (11) and (18). We will not pursue this issue, however, the sole purpose of the discussion being the demonstration that the conditions under which Leftward Spreading occurs are the same for augmentation and e+V coalescence.[6]

Thus, we have argued that all e+V contractions arise through Leftward Spreading which is ordered before /ā/-Fronting and w-Deletion. The other examples of vowel fusion have not yet been thoroughly analyzed. We will take up this task in section 4.3, where we will show that these mergers are in accordance with the general hypotheses developed in chapter 2. Before we go on to the formal description of VC, we will first discuss the phenomenon of Compensatory Lengthening, which will be shown to be another instance of a 'one change-two rules' process.

4.2.2 Compensatory Lengthening

The phenomenon of CL in Ancient Greek has recently received extensive discussion (cf. Ingria 1980, Steriade 1982, Wetzels 1986). In this section we will not go into the intricacies and the exact nature of this phenomenon. The present discussion intends to show that at least two processes are responsible for what we can define as the preservation of syllable weight which goes hand in hand with the loss of a consonant.[7]

The first rule providing support for our claim is our well-known rule of /ā/-Fronting. In (19) below, it is shown that only a subset of the forms undergo this secondary change. The forms in (19a) show that the /ā/ which arises by means of CL undergoes /ā/-Fronting to [ɛ̄], if the conditions of this rule are met, while the forms in (19b) never do:

(19) a:	egam-sa	→ égɛ̄ma	'marry' (aor.)	(cf. gamɔ̂ (fut.))	
	esphal-sa	→ ésphɛ̄la	'trip, deceive'	(cf. sphallɔ̂)	
	ephan-sa	→ éphɛ̄na	'show'	(cf. phanɔ̂)	
	ekran-sa	→ ékrāna	'accomplish'	(cf. kranɔ̂)	
b:	pant-ya	→ pâsa	'all' (nom.sg.fem.)	(cf. pantós)	
	histant-s	→ histā́s	'erecting' (nom.sg.masc.)	(cf. histántos)	
	lūsant-s	→ lū́sās	'having released'	(cf. lū́santos)	

The behavior of sonorant-/s/ clusters provides the second piece of evidence. An underlying /s/ is weakened to [h] if it is not flanked by a non-sonorant segment (cf. Wetzels 1986). The subsequent loss of /h/ is accompanied by the lengthening of the preceding vowel. Secondary [s], which results from spirantization of /t/ before /i/ (cf. section 3.3.3.2) is not affected by the weakening rule. If secondary [s] is part of a nasal-obstruent cluster, nasal deletion and CL takes place. The relevant processes are in (20):

(20) a:	estel-sa	→ éstēla	'send' (aor.)	(cf. stéllɔ̄)
	emen-sa	→ émēna	'remain'	(cf. ménɔ̄)
	egam-sa	→ égɛ̄ma	'marry'	(cf. gamɔ̂)
b:	pha-nti	→ phāsí	'say' (3.pl.pres.ind.)	(cf. phamén)
	lūo-nti	→ lū́ōsi	'loose'	(cf. lū́ontay)
	tithent-ya	→ tithêsa	'placing' (nom.sg.fem.)	(cf. tithénta)

The forms in (19) and (20) illustrate that two types of CL. The first is a coda migration rule by which a coda consonant associates to the vacated C-slot of the deleted consonant with concomitant lengthening of the preceding vowel. The second type is a syllable-weight preservation rule by which the loss of a coda consonant is compensated by the spreading of the features of the preceding vowel to the vacated timing slot (cf. (3) above for an illustration of both CL rules). If the relevant rules are applied in the order /s/-Deletion - First-CL - /ā/-Fronting - Spirantization - /n/-Deletion - Second-CL, the surface forms in (19) and (20) follow straightforwardly, as shown in (21):

(21)	/esphalsa/	/ekransa/	/pantya/	/lūonti/
/s/Deletion:	∅	∅	—	—
First CL:	ā	ā	—	—
/ā/-Fronting:	ɛ̄	—	—	—
Spirantization:	—	—	s	s
/n/-Deletion:	—	—	∅	∅
Second CL:	—	—	ā	ō
	[ésphɛ̄la]	[ékrāna]	[pâsa]	[lū́ōsi]

To sum up, in this section we have discussed two phonological phenomena of Attic: vowel coalescence and compensatory lengthening. Ideally, the resolution of vocalic hiatus would de described by a single rule of vowel coalescence, and the preservation of syllable weight by a single rule of compensatory lengthening. We have shown that this hypothesis cannot be maintained for Attic. If we assumed that a single rule of VC and a single rule of CL were responsible for all the changes observed, we would be faced with a number of ordering paradoxes. For example, both VC and CL have to apply before and after /ā/-Fronting. To solve these ordering paradoxes, we have argued in favor of two processes of vowel fusion, viz. Leftward Spreading and Vowel Coalescence proper, and two processes of compensatory lengthening. Furthermore, it has been shown that the analysis in which two rules of vowel fusion are assumed is not costlier than the alternative one, since the rule of Leftward Spreading has to be assumed in any case.

4.3 The formal description of Vowel Coalescence

In section 4.1 we presented a detailed survey of the relevant VC facts. We also pointed out some inadequacies of previous linear and nonlinear analyses. In particular, we showed that the different behavior of e+a and a+e sequences can be adequately explained on the assumption that all e+V sequences feed into Leftward Spreading, a rule which is independently needed to account for Augmentation and Perfect Reduplication. We will now turn to the remaining contraction facts. It will be shown that Vowel Coalescence proper is activated by resyllabification. We will also illustrate how the various aspects of this phenomenon can be captured within the nonlinear framework developed in the previous chapters. Finally, the empirical problems for the analysis by Sommerstein (1973), brought forward in Ruijgh (1976), will be discussed.

4.3.1 Resyllabification

The claim that vowel coalescence processes are confined to the domain of the syllable must now be put to the test for Attic. This claim implies that heterosyllabic vowels must first resyllabify before merger into a diphthong or monophthong can take place. In chapter 2 we presented evidence from Latin, Korean, Old Portuguese and Chicano Spanish which corresponds to this view. Additional confirmation will be adduced from Attic.

In section 3.4 we argued that Metathesis of Quantity is a retiming process which involves partial resyllabification of a long vowel from one syllable to another. For this analysis to work, we had to assume that the output of MQ undergoes VC. If it is correct that VC applies to resyllabified vowel sequences, we may consider the qualitative change - previously thought to be specific to MQ - as a special case of VC. Since both processes apply to heterosyllabic vowel sequences, it seems quite natural to regard them as instances of one and the same phenomenon. The assumption that only MQ is a partial retiming process, while VC is not, would not bring out this similarity. In addition, we would have to posit a far more complex rule of MQ to account for the quantitative changes occurring at the level of the CV-tier as well as the qualitative changes at the level of the melody.

On the assumption that resyllabification is an integral part of vowel coalescence, we account for the systematic absence of forms in which VC has applied without resyllabification. Hence, forms such as those given in (22) can never reach the surface:

(22) *tīmoɔ̄men (←tīmaɔ̄men)
*philoomen (←phileomen)
*dɛ̄loote (←dɛ̄loete)

Also, inscriptive or other evidence for a transitional stage at which assimilation but not resyllabification had taken place is absent. Lejeune (1972:258), who points out some data that seem to contradict this view, discards them as artificial: "Les formes homériques telles que ὁρόω [horóɔ̄], ὁρόωντοσ [horóɔ̄ntes], ἐάᾳσ [eáāys], αἰτιάασθαι [aytiáāsthay], etc., ne témoignent pas d'un état historiquement intermédiaire entre ὁράω et ὁρῶ, ὁράοντοσ et ὁρῶντοσ, ἐάεισ et ἐᾷσ, αἰτιάεσθαι et αἰτιᾶσθαι, etc.; ce sont des formes artificielles, introduites par les aèdes et représentant un compromis entre les formes non contractes des anciennes formules épiques (dont il importait de conserver le rythme) et la prononciation contracte qui était déjà celle des aèdes et de leur public dans l'usage quotidien de la langue."

Our third argument bears upon the behavior of high vowels in hiatus. As observed earlier, these vowels do not participate in VC proper. If the righthand vowel is [+high], resyllabification takes place, but vowel fusion does not, and if the lefthand vowel is [+high] neither resyllabification nor fusion takes place. If we assume that Vowel Coalescence is preceded by resyllabification, we can treat high and nonhigh vowels on a par: both sets of vowels undergo resyllabification. Conversely, if vowel coalescence took place irrespective of resyllabification, we would have to posit a resyllabification rule to change the output of VC into a tautosyllabic long vowel. In addition, a resyllabification rule would be needed which takes effect if and only if the righthand vowel is [+high]. This analysis has the disadvantage of obscuring the fact that VC and diphthongization serve one and the same purpose: the resolution of vocalic hiatus. The fact that the resulting diphthongs do not become monophthongized will be discussed in section 4.4 below, where we will argue that high and nonhigh vowels are distinct, that is, specified as [+high] and [-high] respectively, at the stage in the derivation where VC applies.

Let us finally take a look at the following Crasis data:

(23) a:	ta hopla	→	thɔ̄̂pla	'shield, weapon' (nom.acc.pl.)
	kay hopɔ̄s	→	khɔ̄́pɔ̄s	'and how'
	pro-hodos	→	phrɔ̄̂dos	'gone'

b: to hīmation → thoymátion 'garment'
kay eyta → kâyta 'and then'
pro-hoymion → phróymion 'introduction, prologue'

These forms seem to refute the claims that resyllabification precedes VC, and that resyllabification is independently motivated. However, the migration of /h/ takes place irrespective of Crasis, as is shown by the examples in (24):

(24) V-herpon → hêrpon 'creep' (imperf.)
V-hoplizdon → hɔ́plizdon 'armor'
V-h̄ra-on → heɔ́rɔ̄n 'see'
V-halɔ̄ka → heálɔ̄ka 'be captured' (perf.)

The /h/ cannot stay if it appears between two sonorants. Generally, it shows up word-initially or changes an unaspirated stop into its aspirated counterpart. By assuming that /h/-migration precedes VC, the intervening /h/ does not present any problem to the analysis defended here. The fact that intervocalic /y/ does not block VC, although we would expect it to block resyllabification, can be accounted for in a similar fashion. As is shown in (25), /y/ is deleted in intervocalic position, if it represents the last segment of the proclitic kay 'and':

(25) kalos kay agathos → kalòs kāgathós 'distinguished'
kay an → kán 'even in that case'
kay egɔ̄ → kāgɔ̄́ 'and I'
kay odūretay → kɔ̄dū́retay 'and moan'(3.sg.pres.ind.Med.)

The loss of /y/ in this word is the remnant of a historical process of intervocalic /y/-deletion, as shown by the examples in (26) (cf. Lejeune 1972, Steriade 1982, Wetzels 1986, among others):

(26)

a: *dweyos	> déos	'fear'	b: *dweynos	> deynós	'fearful'
*phthoyā	> phthóɛ̄	'phthisis'	*dweyma	> dêyma	'object of fear'
*keyatay	> kéatay	'lie down'(ion.)	keymay	> kêymay	'lie down'
*treyes	> trêːs	'three'	eymi	> êymi	'go'

If we assume that a reflex of this historical rule is still operative in the synchronic grammar of Attic, the behavior of yod cannot be used as an argument against our view of VC.

The relationship between MQ and VC, the fact that no forms occur in which VC but not resyllabification has applied, and the behavior of high vowels in hiatus, permits us to draw the conclusion that VC must be characterized as a merger phenomenon applying within the domain of the syllable.

4.3.2 Vowel Coalescence proper

As we have argued that it is a wise strategy to keep the e+V contractions outside the scope of VC proper, we need not be concerned with the difference between e+a and a+e coalescence. As a consequence, it is now possible to restate Sommerstein's (1973) characterization of VC as follows:

(27) a: The output vowel is [+round] iff at least one of the input vowels is [+round]
b: The output vowel is [+low] iff at least one of the input vowels is [+low]
c: The output vowel is [+back] iff at least one of the input vowels is [+back]

If one compares the properties of VC in (27) to the vowel system given in section 3.2 (repeated here for the sake of convenience),

(28)

	i	e	a	o	u	ī	ē	ā	ō	ū
high	+				+	+				+
low			+					+		
round				+	+				+	+

it can be observed that the lexically specified feature values for [round] and [low] are identical to the values which are merged by VC. Furthermore, the derived value for [back] is identical to the value assigned by R-rule (29):[8]

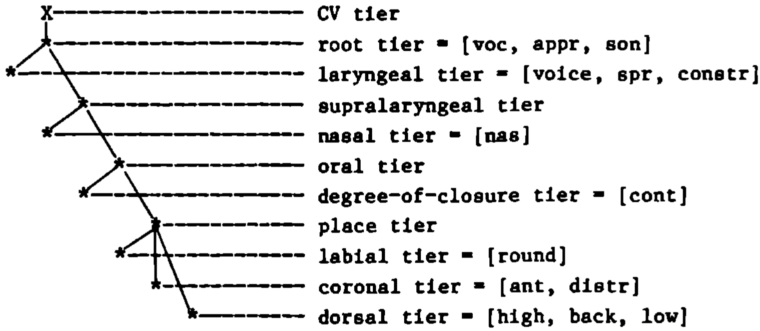
(29) R-rule for [back]
[+low] → [-high, +back]

Hence, VC proper is structure-preserving at the level of the distinctive features. The rule involves the merger of prespecified feature values without changing any of them into the opposite value. As a result, matrices are created which contain more features than the input matrices, and VC therefore has the effect of a lexical feature-filling rule.

A number of clarifications are in order here. As observed, the value [+low] is preserved in the process of coalescence. In order to account for forms such as /dɛ̄lo-ɛ̄te/ → [dɛ̄lɔ̄̂te] 'manifest' (2.pl.pres.subj.) and /dɛ̄lo-ɔ̄-men/ → [dɛ̄lɔ̄̂men] (1.pl.pres.subj.), we must assume that the level-1 rule of Stem Vowel Lowering is ordered before VC. In addition, the observation that VC proper is structure-preserving supports the claim that it must be conceived of as a fusion phenomenon of the lexically relevant features.

This last point calls for some explanation. In chapter 1, we developed a model of feature representation in which features acquire autosegmental status through tier decomposition. As a result single features are organized under higher level constituents or class nodes. This model is an elaboration of the proposals by Wetzels (1986) and Hayes (1986b), and it incorporates earlier insights by Clements (1985) and Sagey (1986). We have argued that a segment takes the following form after the completion of tier decomposition:

(30)



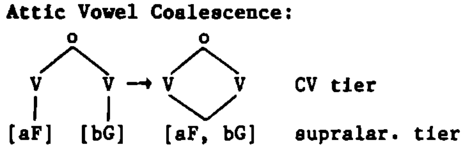
The hierarchical representation of features is mainly justified by the types of assimilation rules occurring in human languages. The geometry in (30) allows only a restricted set of assimilation rules, viz. those that involve the spreading of a single node. The examples in (31) show that both the labial and the dorsal features participate in VC:

(31) a+o → ɔ̄	tīma-omen	→ tīmɔ̄̂men	'honor'
o+ɛ̄ → ɔ̄	dɛ̄lo-ɛ̄te	→ dɛ̄lɔ̄̂te	'manifest'
o+a → ɔ̄	aydo-a	→ aydɔ̄̂	'shame'
ɛ̄+o → ɔ̄	zdɛ̄-omen	→ zdɔ̄̂men	'live'

The assumption that VC entails the merger of two adjacent identical nodes in the feature geometry, enables us to adhere to the strong hypothesis that assimilatory processes can only involve a single node in the feature tree (cf. Clements 1985).

The general properties of VC in (27) reveal that it exhibits all the characteristics of Vowel Coalescence as defined in chapter 2: (i) the quality of the output is a derivative or articulatory compromise of the quality of both input vowels; (ii) the quantity of the output is identical to the sum of the input vowels; (iii) merger of feature nodes is confined to the domain of the syllable, (iv) the trigger and target vowel are indistinguishable, and VC is inherently bidirectional, and (v) all (lexically) specified feature values are preserved. Accordingly, Vowel Coalescence in Attic must be formalized as in (32):

(32) Attic Vowel Coalescence:



In (32) it is arbitrarily assumed that the supralaryngeal nodes merge. However, the geometry proposed allows for other levels at which merger could be defined, e.g. the root or place node. To distinguish merger of the root node from merger of the supralaryngeal or place node, we would need material from a language in which vowel coalescence applies to vowel sequences that differ with respect to the laryngeal features and/or nasality. The vowels of Attic are all [+voice] and

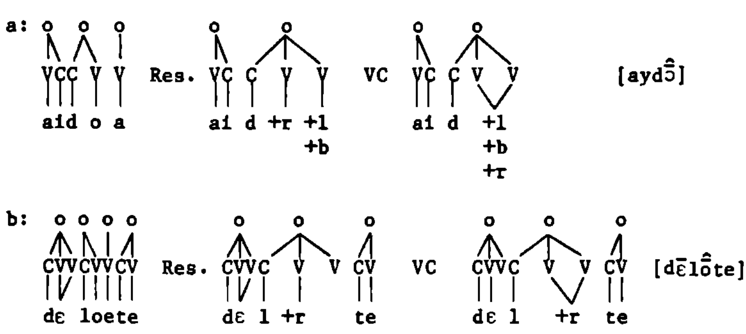
[-nasal] and we therefore cannot solve the indeterminacy by simply looking at the empirical facts. There is, however, a theory-internal argument for taking the supralaryngeal tier as the merging node.

Recall the discussion of tier decomposition in section 1.1.2. We have claimed that single features contained within a matrix or submatrix are unavailable for spreading and delinking rules. They become accessible through tier decomposition, by which mechanism they are assigned tiers of their own. Hence, before tier decomposition has taken place the place-of-articulation features are inaccessible. For the application of a P-rule which refers to this feature set, the expansion rules have to apply first. Assimilatory and dissimilatory rules trigger, so to speak, the rules of decomposition. We introduced the Tier Decomposition Convention as an organizing principle of phonological theory, which takes care of the ordering of the tier decomposition rules in relation to the ordinary P-rules. The TDC is repeated in (33):

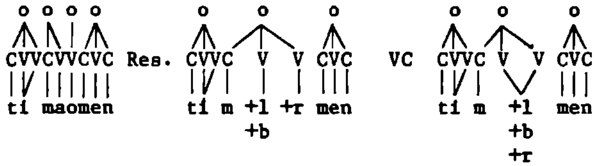
(33) **Tier Decomposition Convention**
A tier decomposition rule T that makes the (class) node F accessible is immediately ordered prior to the first P-rule referring to node F in its structural description.

Since the Attic vowels are redundantly [+cont] and [-nas], and therefore unspecified for these features in underlying representation, the decomposition rule which renders the supralaryngeal features accessible for assimilatory processes will have the side-effect of rendering the place-of-articulation features accessible. Hence, the further application of the decomposition rule which makes the place features accessible is superfluous. A caveat must be added here. Vowels are also redundantly [+voice], and this leaves open the possibility of defining VC as the merger of two adjacent root nodes. We will not seek to solve this indeterminacy here, and more or less arbitrarily assume that merger involves the supralaryngeal node. In chapter 5, we will return to this issue and present empirical evidence from Quebec French for the fusion of the supralaryngeal nodes. Quebec French distinguishes nasal and oral vowels, and it will appear that the output of VC is a nasalized vowel if at least one of the input vowels is [+nas].

In (34) below some sample derivations are given, showing the major characteristics of VC:

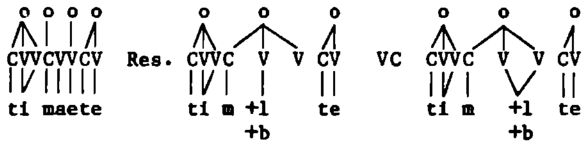
(34)


c:



[tImɔ̂men]

d:

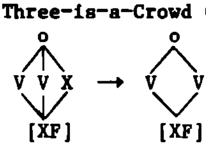


[tImâte]

The formalization of VC in (32) above shows that its changes are purely melody-internal, that is, only the distinct features are re-aligned. Hence, it will be apparent now why the output must be a long vowel. In nonlinear phonology the suprasegmental properties of segments are expressed on independent tiers, and as indicated by the derivations in (34), VC does not affect these levels of representation. VC therefore provides additional support for the principles of CV Phonology developed in Clements and Keyser (1983).

However, the claim that VC does not affect the suprasegmental properties is only partially true. There appear to be data in which one or both input vowels are long. If VC simply merges adjacent supralaryngeal nodes, we derive overlong vowels. Wetzels (1986) - who observes this fact not only in the case of VC, but also for CL and MQ - argues that this ill side-effect of these rules can be resolved by the universal Three-is-a-Crowd Convention:

(35) Three-is-a-Crowd Convention (TCC)

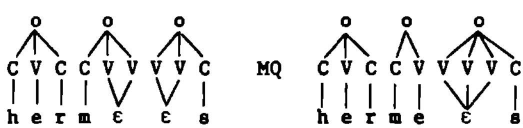


X ranges over C and V

(Wetzels 1986:330)

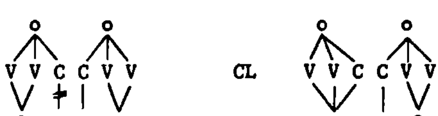
The TCC repairs configurations where the melodic root is associated to more than two timing slots dominated by one syllable node. In (36) below, examples are given to show how the processes discussed can create overlong vowels:

(36) a:



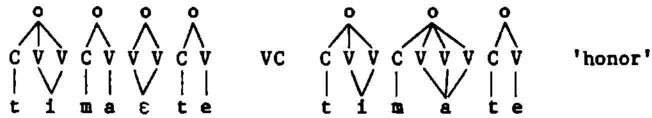
proper name

b:



'purchase'

c:



Before we close the discussion of VC proper, we want to raise one final issue: how can it be explained that e+V sequences which have not undergone Leftward Spreading, resist VC (32)? Forms like pléomen 'sail' (1.pl. pres.ind.) and theós 'god' escape LS because of an underlying /w/ (cf. péplewka) or the Bisyllabicity Condition, respectively. However, VC (32) is not constrained in this way, as shown by /plew-ete/ → [plȇte] 'sail' (2.pl.pres.ind.), and therefore nothing seems to prevent VC (32) from accomplishing the changes *plōmen and *thōs. A plausible answer to this question is all the more necessary, since in theories that posit only a single rule of VC, this problem does not arise. Although, as we have seen, such proposals are faced with inadequacies of a more serious nature, we will attempt to settle this problem within our theory.

We have observed that all prespecified feature values survive the application of VC: no feature value is deleted nor any value changed. This observation is of great importance here, since it indicates that segments which are distinct cannot coalesce. Below, we will argue that in case of the uncontracted e+V sequences, the vowels that make up the sequence are distinct for backness. To see this, we have to reconsider /ā/-Fronting. The formalization of the rule is repeated in (37):

(37) /ā/-Fronting

[+back] → ∅ / X V V

* place tier

– dorsal tier

Condition: X ≠ r, i, e

Notice that the segments /r, i, e/ block /ā/-Fronting in Attic. In order to be able to identify the vowels /i, e/, the feature value for [back] must be specified, since the only feature which distinguishes /i, e/ from /a, o, u/ is the feature [back]. Hence, at the point in the derivation where /ā/-Fronting takes place, the vowels /i, e/, in prevocalic position, must be specified as [-back]. The Redundancy-Rule Ordering Constraint will order the redundancy rules supplying [-back] before /ā/-Fronting.

If [-back] is assigned prior to /ā/-Fronting, all /e/'s in prevocalic position will be specified as [-high, -back, -round]. Hence, the vowels in hiatus in pléomen 'sail' and éar 'spring' are distinct when VC (32) comes into play, and given the characterization of VC as a structure-preserving rule, we predict that it cannot apply in the case of distinct e+V sequences. On the other hand, in underlying forms such as /plew-ete/, the two vowels in hiatus are nondistinct and therefore we expect that after /w/-Deletion nothing will prevent VC from applying.

Contractions like plête show that this prediction is correct.

However, the assumption that the redundancy rules supplying the missing value for [back] is ordered before /ā/-Fronting, and by implication also before VC (32), is seemingly faced with a serious drawback. If the redundancy rules specify all instances of /e/ as [-back], we expect that a+e sequences also remain uncontracted. A brief look at the data reveals that this prediction is false. This problem is due to the introduction of [-back] in all environments, even in environments not referred to by /ā/-Fronting. Below, we will draw the conclusion that this across-the-board application of redundancy rules can be avoided, given an adequate interpretation of the RROC:

(38) Redundancy-Rule Ordering Constraint (RROC)

A redundancy rule assigning "a" to F, where "a" is "+" or "-", is automatically ordered prior to the first rule referring to [aF] in [its] structural description.

(Archangeli 1984:85)

According to (38), a specific redundancy rule which supplies [aF] is ordered immediately before the first rule mentioning [aF] in its structural description, including both focus and environment. Archangeli distinguishes two interpretations of this ordering constraint: a local and an absolute interpretation. The latter entails that if redundancy rule R is ordered by the RROC prior to some phonological rule P_n, then R applies prior to any rule P_{n+1}. The local interpretation cannot be inferred with certainty from the discussion Archangeli devotes to this problem. We will assume here that the local interpretation allows for a specific redundancy rule to apply at several stages in the derivation. If a redundancy rule R is ordered by the RROC before P_n, then R will fill in the missing values in the environment or focus referred to by P_n. This interpretation makes it possible for R to apply before P_n as well as at a later stage in the derivation in other environments.

Archangeli (1984) assumes that the absolute interpretation of the RROC is correct, although she does not present empirical support for her claim. However, the a+e contraction facts constitute a difficulty for this interpretation. For VC (32) to take effect, the /e/ must still be unspecified for backness. If we assume the local interpretation of the RROC, the a+e contractions can be handled in a relatively straightforward way.

The value [-back] has to be present in a prevocalic vowel, in order to block /ā/-Fronting in cases where the vowel /ā/ is preceded by /i, e/. On the local interpretation of the RROC, the redundancy rule supplying the missing value for [back] will specify all front vowels as [-back]. Hence in prevocalic position any vowel is specified for backness, either [+back] or [-back]. On the other hand, the redundancy rules will not supply the missing values for [back] in other environments, including postvocalic position. Hence, postvocalically vowels are still specified as [+back] or [0back].

Archangeli (1984) introduces the RROC to avoid adding ternary power to a theory with binary features. On the local interpretation of the RROC assumed here, we do not add ternary power to the theory, since in prevocalic position vowels are fully specified for backness, while in other environments vowels are either specified as [+back] or unspecified for [back], and therefore a decision in favor of the local or the absolute interpretation can only be made on empirical grounds. The analysis presented hitherto may seem ad hoc and especially designed for the problem at hand. However, we will show that the local interpretation is independently motivated, using data from Japanese and Russian.

In chapter 1, we discussed Rendaku and Lyman's Law in Japanese. In compounds, the initial obstruent of the second constituent becomes [+voice] by Rendaku. However, two voiced obstruents may not cooccur within a single morpheme. In that case, the leftmost obstruent becomes voiceless by Lyman's Law: e.g., the compound kami+kaze 'divine wind' will not become *kamigaze by Rendaku, because of LL. Two points are of interest: (i) a voiced sonorant does not block Rendaku (e.g. iro+gami 'colored paper'), (ii) a sonorant does not become voiceless if there is a voiced obstruent to its right (e.g. mizu+zeme 'water torture'), although voiceless sonorants do occur in Japanese. This means that all sonorants must be unspecified for [voice] when LL takes place. On the absolute interpretation of the RROC, this situation could never occur, since LL refers to [+voice], and all redundancy rules assigning [+voice] would apply before it. On the other hand, under the local interpretation it is possible to avoid this problem: LL refers to voiced obstruents in its structural description, and the RROC will therefore order before LL only those redundancy rules that supply [+voice] in this environment, and it will leave all sonorants unspecified for [voice], since the rule does not refer to them.

A similar point can be made for voicing assimilation in Russian (cf. Hayes 1984, Kiparsky 1985). Consonant clusters agree in voicing in Russian and a voicing assimilation rule is responsible for this. However, voicing can ignore sonorant consonants enclosed by two obstruents (e.g. iz+mcensk-a → i[smc]enska 'from Mcensk'), and furthermore sonorants cannot act as triggers for voicing assimilation (e.g. o[tn]auki 'from science'). To account for the transparency of sonorant consonants, they must be unspecified for voice at the stage in the derivation where voicing assimilation takes place. Consequently, the RROC should not specify sonorants for the feature [voice] until voicing assimilation has taken place. On the local interpretation of the RROC, sonorants will be left unspecified for [voice], since voicing assimilation is confined to obstruents.

Thus, the absolute interpretation of the RROC assumed by Archangeli (1984) faces a number of empirical problems, which the more restricted local interpretation of the RROC avoids. This interpretation enables us to account for the difference between the uncontracted e+V sequences and the contracted a+e sequences in Attic. The former cannot merge, since the input vowels are distinct, whereas the vowels in the latter case are still nondistict at the stage in the derivation where VC applies.

4.3.3 Some recalcitrant data

In his review of Sommerstein (1973), Ruijgh (1976) points out various types of data that contradict Sommerstein's analysis of Vowel Contraction. We will now discuss how these forms fare in our approach. A survey of these problematic cases, which have been given in section 4.1, are repeated in (39) for convenience:

(39) a: néos 'new', theós 'god'
     b: boós 'ox', grāós 'old woman' (gen.sg.)
     c: glukéos (gen.sg.masc.), glukéa (nom.pl.ntr.) 'sweet'
     d: póleɔ̄s 'state', hippéɔ̄s 'horseman' (gen.sg.)
     e: endeā̂ 'lacking', hugiā̂ 'healthy'
     f: khalkā̂ 'copper', ostā̂ 'bone' (nom.pl.ntr.)
     g: náwtō 'sailor', tamíō 'steward' (gen.sg.masc.)
     h: alε̄thē̂s 'true', triε̄́rēs 'trireme' (acc.pl.)

The forms in (39a) have already been accounted for. Since the left input vowel is the default vowel /e/, they could be subject to Leftward Spreading (16). However, as shown in section 4.2.1, LS is subject to the Bisyllabicity Condition, which rules out vowel merger in bisyllabic forms such as theós..etc.

We cannot appeal to an underlying intervocalic /w/ or the Bisyllabicity Condition in cases such as those in (39b). The genitive singular bo.ós is problematic in two respects. First, we have to explain why the gen.sg. of bôws 'ox', and grâws 'old woman' do not undergo VC. Secondly, the two input vowels of bo.ós are identical, and it can be observed that such vowels show the strongest tendency to merge (cf. pléomen vs. plē̂te 'sail').

Kiparsky (1967), Allen (1973), Sommerstein (1973), following the Ancient Greek grammarians, observe that third-declension nouns undergo accent shift in the genitive and dative if and only if the stem is monosyllabic underlyingly or has become monosyllabic by syncope. The examples in (40) show this shift of accent:

(40)	nom.sg.	gen.sg.	dat.sg.	gen.pl.	
a:	patε̄́r	patrós	patrí	patérɔ̄n	'father'
	mε̄́tε̄r	mε̄trós	mε̄trí	mε̄térɔ̄n	'mother'
	anε̄́r	andrós	andrí	andrɔ̄̂n	'man'
b:	phléps	phlebós	phlebí	phlebɔ̄̂n	'vein'
	thríks	trikhós	trikhí	trikhɔ̄̂n	'hair'
	elpís	elpídos	elpídi	elpídɔ̄n	'hope'
	gígās	gígantos	gíganti	gigántɔ̄n	'giant'
c:	bôws	boós	boí	boɔ̄̂n	'ox'
	grâws	grāós	grāí	grāɔ̄̂n	'old woman'
	nâws	neɔ̄́s	nε̄í	neɔ̄̂n	'ship'

De Haas and Hermans (forthcoming) describe this shift as a rule of Foot Migration (41):

(41) Foot Migration (FM)

$$(\overset{*}{*}\ .) \rightarrow (.\ \overset{*}{*})$$

Rule (41) changes a trochaic foot into an iamb, in case main stress is located at the left edge of the word domain. The effects of FM are illustrated in (42):

```
(42) a:   *            *
        ( * . )      ( . * )
        ( o o )  FM  ( o o )
        patros       patros        [patrós]

     b:       *
        ( .   * . )
        ( o)( o o )  FM   n.a.
         pa  terɔ̄n                 [patérɔ̄n]

     c:   *              *
        ( * . )      ( . * )
        ( o o )  FM  ( o o )
         bo os        bo os        [boós]
```

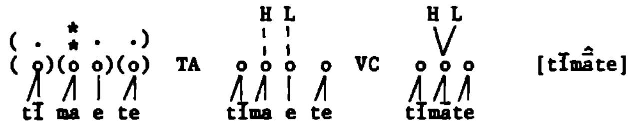
In (42c) Foot Migration takes place, but resyllabification and VC do not. The question is why resyllabification is blocked after accent shift has taken place.

Suppose we assumed that resyllabification is ordered before FM, in which case the environment for FM would be destroyed for words like boos. This ordering would be a bleeding one, and highly marked according to Kiparsky (1968, 1971). If, on the other hand, resyllabification occurred after FM, it would alter the output of accent shift, rendering this rule opaque in the sense of Kiparsky (1971). In view of the fact that FM is fully transparent in the consonant stems in (40), transparency considerations seem to play a prominent role in the constraint on resyllabification. We can express this formally by assuming that resyllabification does not apply inside an iambic foot (We will refer to this as the Iambic-Foot Condition). Leo Wetzels (personal communication) points out a striking similarity between the Bisyllabicity Condition and the Iambic-Foot Condition. Both conditions rule out resyllabification in bisyllabic words, and therefore it seems plausible that the Iambic-Foot Condition is a subcase of the general Bisyllabicity Condition. The assumption that resyllabification and VC take place after accentuation is legitimate, since otherwise we would not be able to account for the fact that contracted forms of the type -VVCVC$_0$ systematically bear a circumflex accent (= falling tone), while underlying -VVCVC$_0$ forms can bear an acute accent (= high tone) on the antepenult, as shown in (43):

(43) a: tīmáete → tīmâte	'honor'	b: géphūra	'bridge'
philéete → philête	'love'	éwthūna	'scrutiny'
dēlóomen → dēlômen	'manifest'	hístēmi	'set'(pres.ind.)

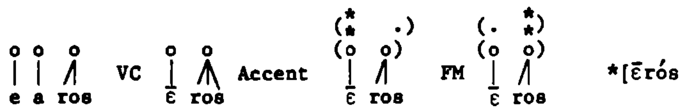
The forms in (43b) show that the weight of the penultimate syllable is irrelevant to accent assignment. Hence, if VC applied before the accent rules, we would expect forms like *tī́māte and *phílēte. If, on the other hand, accent is assigned prior to VC, the forms in (43) can be regarded as the regular outcome of the same accent rule which assigns word accent to the antepenult. The claim that VC accomplishes a purely melody-internal change without affecting the suprasegmental properties of the sequence as a whole finds independent confirmation in the accent properties, since the original tonal pattern is preserved after VC, as is shown in (44):[9]

(44)



Furthermore, if VC is ordered before the rules of word accent, the contracted form ε̂ros (← /éar-os/) 'spring' (gen.sg.) is expected to show up as *ε̄rós as a result of FM:

(45)



Having provided an explanation for the aberrant behavior of the words in (39b), let us now turn to another set of exceptions. The examples in (39c) belong to the paradigm of the adjective glukú-s 'sweet' (nom.sg.masc.). If the stem ends in /u/, adjectives are formed in -us (masculine), -eya (feminine) and -u (neuter). A closer look at the masculine and neuter paradigms reveals that resyllabification and VC do not take place, except where the case ending is -i (dat.sg.) or -e (nom.acc.du./nom.acc.pl.masc.):

(46) a: masculine	b: neuter	
glukús	glukú	nom.sg.
glukún	glukú	acc.sg.
glukéos	glukéos	gen.sg.
glukêy	glukêy	dat.sg.
gluke̊̂	gluke̊̂	nom.acc.du.
glukéoyn	glukéoyn	gen.dat.du.
gluke̊̂s	glukéa	nom.acc.pl.
glukéɔ̄n	glukéɔ̄n	gen.pl.
glukési	glukési	dat.pl.

We observe that the stem in (46) has two allomorphs, one ending in /u/, and one ending in /e/. In section 3.3.1, we claimed that this alternation is due to a stem-vowel delinking rule which delinks the vocalic features, in this case [+high, +round], from the CV tier resulting in the default vowel /e/. If the stems which undergo this special delinking rule are lexically marked as [-Leftward Spreading], we can account for the surface forms in (46). VC cannot apply to the e+o and e+a sequences, since the vowels constituting these sequences are distinct at the stage in the derivation where VC applies. The e+e sequences are eligible for merger, since these vowels are nondistinct. Finally, the sequences of e+i are distinct, but nothing prevents them from fusion into a diphthong.

The examples in (39d) are instances of the Attic Genitive. In general the genitive singular suffix appears at the surface as -os. However, Metathesis of Quantity can change this suffix into -ɔ̄s. In the Attic dialect some stems ending in /i/ or /u/ take the genitive suffixes -ɔ̄s/ -ɔ̄n, suggesting an application of MQ:

(47)	nom.sg.	gen.sg.	gen.pl.	
	pólis	póleɔ̄s	póleɔ̄n	'state'
	pɛ̂khus	pɛ́kheɔ̄s	pɛ́kheɔ̄n	'cubit'

This unexpected behavior of these words is not an isolated fact. The genitives in -eɔ̄s and -eɔ̄n allow the acute accent on the antepenult, although this type of accentuation is generally excluded in words containing a long vowel in the final syllable (cf. ánthrɔ̄pos vs. anthrɔ́pō 'man'). The genitives of the nouns in -is and -us can be viewed as analogical extensions, after the model provided by regular cases like hippéɔ̄s 'horseman', basiléɔ̄s 'king'..etc. It appears that the rule of MQ overapplies to the forms in (47), which do not satisfy the structural description of the rule. We will not provide a detailed analysis of these data, and regard them as truly exceptional.

The more general question is why the output of MQ does not usually undergo VC. The explanation for this is not difficult to find. We have characterized MQ as a partial retiming process which involves the resyllabification of the second half of a long vowel, while VC is a full retiming process which results in the loss of an entire syllable node. This suggests that the two processes are in an elsewhere relationship. The processes are distinct to the extent that the output of MQ consists of two syllable nodes, whereas VC creates a single syllable. Furthermore, the structural description of MQ is defined over a subset of the sequences that undergo VC. As a consequence, the Elsewhere Condition brings about the ordering MQ - VC. Additionally, if MQ applies to a particular form, the same condition will block the application of VC.

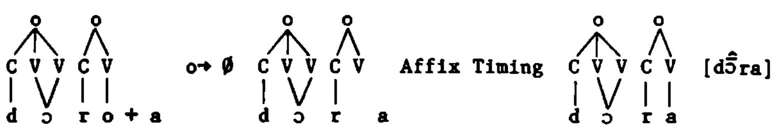
The forms endeâ and hugiâ in (39e) do not present any problem for the theory advanced here, as is shown in section 4.2.1 above. We have argued that e+a sequences undergo Leftward Spreading which yields the long vowel /ā/. Next in line is /ā/-Fronting which changes underlying /ā/s and /ā/s arising by Leftward Spreading into [ɛ̄], unless /ā/ is preceded by the front vowels /i/ or /e/.

Let us now turn to the set of exceptions in (39f). Ruijgh (1975) argues that the stem of these second declension nouns ends in the long vowel /ō/. Thus, the underlying stems are khalkō- 'copper', khrusō- 'of silver', ostō- 'bone', and kanō- 'basket'. The problem is how to account for the long /ā/ in the nominative/accusative plural, which shows up irrespective of the preceding segment. The problem is twofold: (i) how to account for the absence of [+round], and (ii) how to account for the absence of /ā/-Fronting. We will discuss these problems one after the other. Some regular second declension neuters are given in (48):

(48) nom.sg. nom.acc.pl.

dɔ̄̂ro-n	dɔ̄̂ra	'gift'
sū̂ko-n	sū̂ka	'fig'
hīmátio-n	hīmátia	'outer garment'

We observe that the stem vowel /o/ does not show up in these nominative/accusative plural forms either. We will, following the analysis by Ruijgh (1975), assume that the second declension neuters have two stem allomorphs: one ending in /o/ and one ending in /e/, where the latter is the result of the stem-vowel delinking rule (cf. 3.3.1). Ruijgh argues that the nominative/accusative ending solely consists of the features [marginal] and [open] (these features roughly correspond to our features [back] and [low]), which manifest themselves phonetically by coloring the preceding stem vowel. A reinterpretation of Ruijgh's abstract nominative/accusative plural morpheme in terms of CV-Phonology readily comes to mind. CV-Phonology allows us to represent this morpheme as a floating or untimed suffix, that is, a suffix which solely consists of a feature matrix. Under these assumptions, the nominative/accusative plurals can be described in the following way:

(49) 

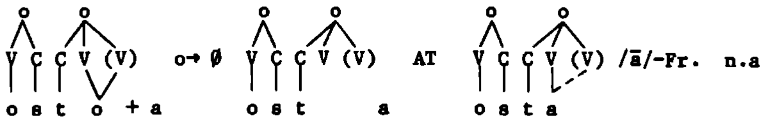
The problematic forms in (39f) differ in one important respect from the regular forms in (48) in having a long vowel in the singular and plural, as is shown in (50):

(50) nom.sg. nom.acc.pl.

ostō̂n	ostā̂	'bone'
kanō̂n	kanā̂	'basket'
khrusō̂n	khrusā̂	'of silver'

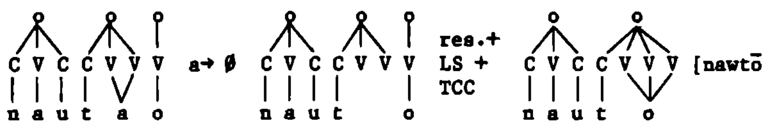
In section 3.3.3.1 we discussed Stem Vowel Shortening which is responsible for the length alternations in stems (cf. khɔ̄́rā (nom.sg.) vs. khɔ̄̂ray (nom.pl.), 'land', tīmɛ̄́ vs. tīmáy 'honor'). Nouns of the o-declension do not participate in Stem Vowel Shortening for the simple reason that their stem-final vowel is usually short to begin with. Clear exceptions to this observation are the data in (50) in which the stem-final vowel shows up as long [ō] on the surface.

The absence of SVS in the plural forms of (50) calls for an explanation. If we assume that the right-peripheral V-slot is extrametrical, i.e. invisible for the shortening rule, we can account for the absence of /ā/-Fronting in a natural way, as the structural description of /ā/-Fronting is now not met. In (51) below, the derivation of ostā̂ 'bone' (nom.acc.pl.) is given as an illustration:

(51) 

The derivation in (51) shows that the two problems concerning the data in (39f) are explained by assuming a stem-vowel delinking rule which results in the allomorphic alternation ostō-ostē-. The additional assumption that the stem-final V-slot is extrametrical enables us to account for the absence of /ā/-Fronting.

The genitive singular masculines in (39g) are exceptional, since we expect that the stem-final /ā, ɛ̄/ and the genitive singular ending /o/ merge into /ɔ̄/ (/nawtā-o/ → *[nawtɔ̄]). These genitive singulars can be described by stem vowel delinking. If the stem vowel /ā/ is delinked from its skeleton positions, the output can be obtained by Leftward Spreading and the TCC (35), as is shown in (52):

(52) 

Finally, let us consider the third-declension nouns in (39h). In view of the accusative plural phúlak-as 'watchman', léont-as 'lion' and rhɛ́tor-as 'orator', we expect forms such as *alɛ̄thɛ̄s and *triɛ̄rɛ̄s, derived from the underlying representations /alɛ̄the-as/ and /triɛ̄re-as/. Both Kühner-Blass (1890) and Goodwin (1894) assume paradigm leveling for the cases at hand. They point out that the synchronization of the nominative plural and accusative plural is widespread. In the masculine and feminine, the nominative and accusative plural are homonymous through VC and CL (e.g. pole-es → pólēs (nom.pl.), polens → pólēs (acc.pl.) 'state'). Probably, these masculine/feminine forms served as a model for the forms in (39h). The nominative plural of alɛ̄thɛ́s 'true' is alɛ̄thē̂s which is a result of e+e coalescence. The tendency to synchronize the nominative and accusative plural has led to the suppletion of the expected accusative plural form alɛ̄thɛ̄s in favor of the nominative plural form alɛ̄thē̂s.

The problematic forms in (39), then, fall into three major categories. The first set of data are bisyllabic underlyingly, and this prevents Leftward Spreading from applying. The second set of data, which undergo neither resyllabification nor VC, are the third-declension nouns in (39b). We have argued that resyllabification does not occur if the vowels in hiatus are contained within an iambic foot, possibly to keep Foot Migration transparent. The third set contains forms that show unexpected VC properties. We have suggested, following others, that analogy has played an important role here. However, we use the notion of analogy in a particular, theoretically quite restricted sense. First of all, we express analogy by introducing diacritic rule features such as [+Rule R] (= overapplication) or [-Rule R] (= underapplication). Diacritic rule features are used, for example, to account for the augmented forms ê̄khon 'have' (1.sg.imperf.ind.) which do not undergo Stem Vowel Lowering (cf. section 3.3.2), and to account for the forms in (39d) which have unexpectedly undergone Metathesis of Quantity. Secondly, we express analogy by introducing special stem-vowel delinking rules which are responsible for stem-vowel alternations of the type /o/-/e/, /u/-/e/, /i/-/e/, and /a/-/e/. The forms in (39) exhibit precisely these alternations: /i,u/-/e/ alternation in (d), /o/-/e/ alternation in (f), and /a/-/e/ alternation in (g,h). Hence, these forms are instances of the latter type of analogy by which the melody is delinked from the skeleton resulting in the default vowel.

4.3.4 Recapitulation

The aim of this section has been to provide a formal characterization of VC proper and to test whether the hypothesis developed in chapter 2 was sufficient to account for the complex Attic forms. It has turned out that VC, as expected, must be formalized as a syllable-internal vowel-merger operation by which nondistinct feature matrices coalesce. A number of arguments have been brought forward to support the claim that VC is fed by resyllabification. Furthermore, we have provided an account of the uncontracted e+V data such as pléomen..etc. They cannot undergo Leftward Spreading, because of an underlying intervocalic /w/, and, in addition, VC proper cannot take place, since at that stage in the derivation the vowels are distinct for backness. Given the proper interpretation of the RROC, the a+e sequences will not be rendered distinct, and consequently, VC is free to apply. Finally, we have discussed some forms problematic to Sommerstein's (1973) analysis, and have suggested a possible way of analyzing them within the limits of the theory proposed.

4.4 The behavior of high vowels in hiatus

So far we have several times referred to the behavior of high vowels in hiatus. It was observed that high vowels in postvocalic position undergo resyllabification into diphthongs, while high vowels in prevocalic position do not undergo resyllabification. Below, we will provide an account for the non-application of VC proper, if one of the input vowels is [+high].

4.4.1 Prevocalic high vowels

LeJeune (1972), among others, observes that a vowel hiatus remains stable if the left input vowel is [+high]. He provides an account of this situation involving a 'homorganic intervocalic glide': "Même dans les langues qui ne possèdent pas de semi-voyelle y, w, ẅ, un i, un u, un ü en hiatus dégagent normalement dans le prononciation un bref élément consonantique, souvent inaperçu de celui qui parle (ia tend a se prononcer iya, ua : uwa, üa : üẅa). Il en etait ainsi en grec ancien" (LeJeune 1972:163).[10]

Within the SPE framework a homorganic glide insertion rule will take the following form:

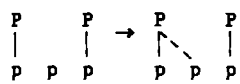
(53) Homorganic Glide Insertion

$$\emptyset \rightarrow \begin{bmatrix}+\text{cons}\\ +\text{high}\\ \alpha\text{back}\\ \beta\text{round}\end{bmatrix} / \begin{bmatrix}+\text{syll}\\ \alpha\text{back}\\ \beta\text{round}\end{bmatrix} — [+\text{syll}]$$

However, rules such as (53) cannot explain why the glide is homorganic with the preceding vowel, and a rule inserting a [$-\alpha$back, $-\beta$round] glide in the same environment would be equally marked according to SPE's own evaluation procedure. In the present nonlinear framework it suffices to insert an empty C-slot intervocalically. The universal Left-Precedence Clause (54), proposed by Clements (1976), will take care of the spreading of the melody of the lefthand vowel to the inserted C-slot:

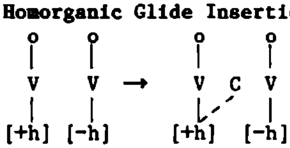
(54) Left-Precedence Clause

Given configurations in which one or more free (i.e. unassociated) P-bearing units are flanked on both sides by bound (i.e. associated) P-bearing units, associate from the left. E.g.:



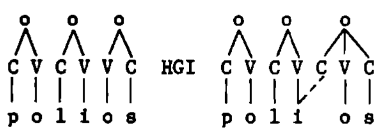
The nonlinear counterpart of HGI (53) is given below:

(55) **Homorganic Glide Insertion:** (nonlinear version)



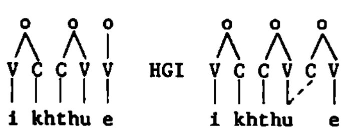
It will be clear now why VC does not take place, if the lefthand input vowel is [+high]. HGI (55) destroys the proper environment for resyllabification, as indicated by the derivations in (56):

(56) a:



Res. n.a. VC n.a. [póliyos]

b:



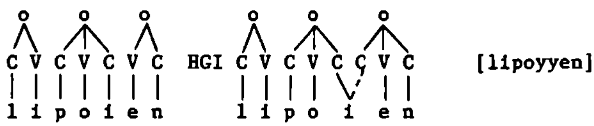
Res. n.a. VC n.a. [ikhthuwe]

Having provided an explanation for the absence of resyllabification in the case of vowel sequences where the lefthand vowel is [+high], let us now turn to the treatment of prevocalic diphthongs. The examples in (57) show that the second half of the diphthong is geminated:

(57) a: /lip-oy-mi/ → [lípoymi] (1.sg.pres.opt.) 'leave'
/lip-oy-en/ → [lípoyyen] (3.pl.pres.opt.)

b: /e-kelew-sa/ → [ekeléwsa] (1.sg.aor.ind.) 'command'
/kelew-ɔ̄/ → [keléwwɔ̄] (1.sg.pres.ind.)

It seems intuitively correct to relate the forms in (57) in one way or another to the forms having a high vowel in prevocalic position. If we slightly modify HGI (55), such that it also inserts an empty C-slot after the second half of a diphthong, the data in (57) can be handled naturally:

(58)


This discussion reveals that the resolution of vocalic hiatus depends on the segmental make-up of the vowels. If the first syllable ends in a [+high] segment, the hiatus is resolved by HGI, and if it ends in a [-high] segment, the hiatus is resolved by resyllabification (and VC).

4.4.2 Postvocalic high vowels
The behavior of high vowels constituting the righthand environment for VC has already been referred to in the previous sections. We have argued that the absence of VC proper can be accounted for if resyllabification creates the environment for VC to apply. If the postvocalic vowel is [+high], resyllabification brings about a change in the CV skeleton if the preceding vowel is [-high], a fact that can be expressed by changing the V-slot dominating a high vowel into a C-slot. Furthermore, VC cannot take place for yet another reason: the nonhigh and high vowel in hiatus will be distinct when resyllabification takes place. The question why this is so is related to the functioning of Stem Vowel Lowering.

Stem Vowel Lowering marks long [-high] vowels as [+low] at level-1. Doing so, it accounts for a gap in the data, because in stems only /ɛ̄, ɔ̄/ appear underlyingly. After CL and VC, however, there are four long mid vowels, viz. [ē, ɛ̄, ō, ɔ̄]. The absence of the long closed mid vowels inside stems follows immediately if SVL is ordered before CL and VC. The rule of SVL, though, explicitly refers to the feature [-high] and the RROC will order the redundancy rules supplying this value immediately before it. As a consequence, a sequence of [-high]-[+high] vowels is distinct when VC takes place. Since VC must be structure-preserving, its application will be blocked.

We have provided two reasons for the absence of VC if a high vowel appears in postvocalic position. It seems intuitively correct that distinctness is the principal reason, and the change at the CV tier the secondary one. This hypothesis enables us to formalize Diphthong Formation straightforwardly:

(59) Diphthong Formation

```
             o
            / \
V → C /    V   _
               |
             [+h]
```

In case of identical high vowels, the vocalic features will merge by VC. Consequently, (59) cannot apply because of the Linking Constraint. If the tautosyllabic vowels are distinct, VC may not apply, given its definition, and subsequently, (59) will accomplish a change on the CV tier.

We can conclude from the above discussion that there are two reasons for the absence of VC proper if the righthand input vowel is [+high]. The fundamental reason is the notion of distinctness, and the secondary reason concerns the position of postvocalic high vowels in the syllable. The derivation of the form géray 'prize' (dat.sg.) is given in (60):

```
(60)  o   o  o          o      o                  o    o
     / \ / \ |         / \   / | \               / \  / \
     C V C V V   Res.  C V  C  V  V   VC  n.a. DF C V  C V C   [géray]
     | | | | |         | |  |  |  |               | |  | | |
     g e r a i         g e  r -h +h               g e  r a i
                              +l
                              +b
```

We have accounted for the behavior of high vowels in hiatus by referring to their specific properties with respect to syllabification. If the prevocalic vowel is [+high], Homorganic Glide Insertion will take place, destroying the environment for resyllabification. If the postvocalic vowel is [+high] resyllabification will apply freely. The absence of VC proper follows from melodic properties of the vowels in hiatus. We have claimed that VC merges nondistinct tautosyllabic vowels, but in case one of the input vowels is [+high], coalescence cannot take place, since the nonhigh vowels are already specified as [-high] by the redundancy rules proposed for Attic.

4.5 Summary

In this chapter a formal description of VC has been presented, showing that the resolution of vocalic hiatus is the result of Leftward Spreading and VC proper. We have shown that this analysis is supported by two independently motivated processes: /ā/-Fronting and /w/-Deletion, and one rule-specific condition, viz. the Bisyllabicity Condition. In section 4.2.1, we have pointed out that: (i) the output of Leftward Spreading undergoes /ā/-Fronting, while the output of VC does not, (ii) Leftward Spreading is blocked by an underlying intervocalic /w/, while VC is not, and (iii) Leftward Spreading, unlike VC proper, does not take place, if the input word is bisyllabic. Next (section 4.3.1), we have proposed to define VC as a syllable-internal vowel-merger operation, where resyllabification is an integrated part of vowel coalescence. This hypothesis allows us to consider the qualitative changes, which were previously thought to be specific for Metathesis of Quantity, as a special case of VC. Secondly, on the supposed relation between resyllabification and VC, we account for the systematic absence of forms in which VC has taken place without resyllabification. Finally, we have looked at the behavior of postvocalic high vowels in hiatus. These vowels undergo resyllabification, and combine with the preceding vowel to produce a diphthong. If it were assumed that vowel coalescence takes place irrespective of resyllabification, this would obscure the fact that VC and diphthongization serve one and the same purpose: the resolution of vocalic hiatus. These considerations have led to the conclusion that the simplest grammar of Attic is one in which resyllabification is the ultimate cause of VC and diphthongization, and accordingly, the ultimate cause of the resolution of vocalic hiatus. Finally, we have considered sequences where one of the input vowels is [+high]. It turned out that the absence of both resyllabification and VC, when the prevocalic vowel is [+high], is a consequence of Homorganic Glide Insertion. If the postvocalic vowel is [+high], the hiatus is resolved by resyllabification. Subsequent VC is not allowed, since it cannot apply to sequences which are distinct without being non-structure preserving at the level of distinctive features.

Footnotes

1: For the moment we will ignore the merger of two identical high vowels into a long vowel, e.g. /ophi-idion/ → [ophī́dion] 'little snake'. We will return to these forms in section 4.2.1.

2: The Crasis facts differ in some respects from the VC facts. The most important differences are the following:
(i) if the first, clitic-like word ends in a yod, this segment disappears, e.g. /kay epeyta/ → [kā́peyta] 'and then'. In the optative mood -y is added to the tense stem, but intervocalically it shows up as a geminate, e.g. /lip-oy-en/ → [lípoyyen] 'leave' (3.pl.pres.opt.).
(ii) if the second input word is /a/-initial, the output of Crasis is always /ā/ in Attic, irrespective of the quality of the preceding vowel, e.g. ho anḗr → hānḗr 'the man'. Given the characteristics of VC we expect *hɔ̄nɛ̄r. This form surfaces in other dialects (e.g. Doric) and this indicates that the Attic forms need a special analysis.
Apart from these differences VC and Crasis can be regarded as one and the same process.

3: The data are taken from standard philological studies, notably Kühner-Blass (1890), Goodwin (1894), Schwyzer (1939) and Lejeune (1972).

4: Other examples of ā+V coalescence are not attested. This gap is mainly the result of two independent changes. First, underlying /ā/ becomes [ɛ̄] by means of /ā/-Fronting, e.g. /tīmā-/ → [tīmɛ̄-] 'honor', and secondly, Stem Vowel Shortening shortens long vowels under certain morphological conditions, e.g. the noun stem /khɔ̄rā-/

'land' becomes [khɔ̄ra-] in the plural, and the verb stem /drā-/ 'do' becomes [dra-] in the present tense system.

5: The graphic representation of resyllabification and VC as two ordered processes does not mean that they are actually ordered. The claim is that both changes take place simultaneously.

6: If this abstract analysis is accepted, it should be borne in mind that it is not supported by synchronic alternations, and consequently is exposed to the criticism raised by e.g. Kiparsky (1973).

7: Whitney (1889:84), as reported in Wetzels (1986:300), characterizes CL as "the absorption by a vowel of the time of a lost following consonant."

8: In section 3.2 we noted that R-rule (29) must be ordered before the level-1 rule of Stem Vowel Lowering. VC must be ordered after the latter rule, since otherwise we would derive *dε̄lɔ̂̄te from underlying /dε̄lo-e-te/ 'manifest'.

9: De Haas and Hermans (forthcoming) devote a detailed discussion to the relation between accentuation and tone assignment. It is argued that the HL-melody is first inserted by rule and subsequently associated with the vowels, one-to-one from left to right, starting with the vowel which bears word accent. This procedure is not language-specific, but reflects the general way of tone association in pitch-accent languages (cf. many of the contributions to Clements and Goldsmith 1984). We will not pursue this matter any further, since it is irrelevant to the points discussed here.

10: Attic orthography never indicates transitional glides. However, they are always recorded in Mycenaean, e.g. i-je-re-u for Attic hieréws 'priest' and ku-a-no for Attic kúanos 'lapis lazuli', and regularly in the Pamphylian dialect.

5.0 Introduction

We have proposed that vowel coalescence must be regarded as a purely melody-internal merger phenomenon, which leaves the suprasegmental properties of the input sequence unaffected. Furthermore, we have claimed that resyllabification is an integral property of VC, and that, therefore vowel merger is confined to the domain of the syllable. In this chapter we will explore VC processes in a variety of languages. In the literature these can be found subsumed under the headings of vowel merger, vowel fusion or vowel contraction. We will show that only a subset of these phenomena share the characteristics of VC explored in chapter 2 (in languages such as Classical Sanskrit, Korean, Quebec French, Old Portuguese). In the remaining cases the merger of two vowels in hiatus is a by-product of independently motivated language-specific processes (e.g. in Tunica, Kasem, Kikuyu). Lack of space prevents us from an analysis as thorough as that provided for Ancient Greek in the previous chapters. As a consequence, the analyses of this chapter may strike one as perhaps fragmentary, especially where decisions with respect to the representation of the vowel inventories are concerned. The most important goal is to verify the general theory of VC developed in chapter 2 and expanded in chapter 4. The discussion will serve another purpose as well, which is to fill empirical gaps in our proposals so far. For example, we will discuss VC in Quebec French, since it provides crucial evidence for the claim that merger involves adjacent supralaryngeal nodes. Furthermore, VC in Korean and Rotuman will receive attention because in these languages VC turns out to be structure-preserving at the micro (i.e. distinctive feature) level but not at the macro (i.e. phoneme) level. This is expected given our theory, since we have characterized VC as the merger of nondistinct feature matrices.

5.1 Quebec French

Vowel Coalescence in Quebec French is interesting, because the language distinguishes between nasal and oral vowels. This opposition enables us to readdress a point brought up earlier in section 4.4.2 regarding the feature nodes which merge by means of VC. We hypothesized that the supralaryngeal nodes coalesce, and thus predict that the features dominated by this node in the feature tree are involved and preserved, that is, we expect that the prespecified nasal features and place features will survive.

The rule of vowel coalescence, in Quebec French, is a late phonological rule, and in the majority of cases applies across word boundaries, although word-internal contractions also occur (e.g. [elɛktrisite] → [ɛ̄ktrisite] 'electricity'). This phenomenon has received extensive attention in Dumas (1978) and Rochette (1980), the former working in a linear framework and the latter in a nonlinear (metrical) one. The authors do not agree with respect to the nature of the underlying vowel system. Dumas characterizes the closed and half-closed vowels as [+tense] and the open and half-open vowels as [-tense]. Rochette, on the other hand, assumes an underlying length contrast, where all long vowels are [+tense] and the short ones [-tense]. Furthermore, she assumes that the open and half-open vowels are [+low]. We will follow Rochette's characterization, which is given in (1):

(1)

	[-back]				[+back]		
	[-round]		[+round]		[-round]	[+round]	
[+high]	i	I	y	Y		u	U
[-low]	e/ẽ	E	ø	Ø		o	O
[+low]	ɛ	a/ã	œ/œ̃		(ɑ)	ɔ/ɔ̃	
[tense]	+	-	+	-	+	+	-

In word-final position all vowels appear as short tense vowels, cf. [fɔtOgrafi] vs. [fɔto]. Hence, for VC the left input vowels are usually short and tense. Furthermore, the vowel /ɛ/ is usually realized as [a] in word-final position (e.g. le lait [ləla] 'the milk', avait [ava] 'had'). Word-final /a/s are realized as [ɔ] (e.g. ananas [ananɔ] 'pineapple', ne..pas [nə..pɔ] 'not'). Finally, a long nasal /ã̄/ is phonetically realized as [ɑ̃̄] (e.g. changer [šɑ̃̄že] 'change'). Rochette (1980) argues that the rule of /a/-labialization takes place before final tensing and shortening, while the rules of /ɛ/-laxing and /ã̄/-backing take place very late in the derivation. We will return to these changes below.

The possible combinations of vowels and their contracted versions are summarized in table (2) below. Vowel length is not indicated, since all output vowels are long, which we expect, given the assumption that VC induces purely melody-internal changes. For Ancient Greek we have observed that the tonal melody of the input is also preserved, and the same is true for the stress pattern in Quebec French. The output vowel bears stress if either of the input vowels does (e.g. je vais fumér la cigarétte [žvɔfymásigarɛ́t] 'I am going to smoke the cigarette').

(2)

		i	y	e	ø	ɛ	œ	a	ɔ	o	u	ẽ	ã	ɔ̃	œ̃
	i	-	-	e	-	-	-	a	-	o	-	ẽ	ã	ɔ̃	œ̃
	y	-	-	e	-	-	-	a	-	o	-	ẽ	ã	-	œ̃
	e	-	-	e	-	-	-	a	-	o	-	ẽ	ã	-	œ̃
	ø	-	-	e	-	-	-	a	-	-	-	-	ã	-	-
/ɛ/ →	a	ɛ	œ	ɛ	œ	ɛ	-	a	ɔ	ɔ	ɔ	ɛ̃	ã	ɔ̃	œ̃
	œ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
/a/ →	ɔ	-	œ	ɛ	œ	ɛ	-	a	-	ɔ	ɔ	ɛ̃	ã	-	-
	ɔ	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	o	-	-	e	-	-	-	a	-	o	-	ẽ	-	-	-
	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	ẽ	-	-	ẽ	-	-	-	-	-	-	-	ẽ	ã	-	-
	ã	-	œ̃	ɛ̃	œ̃	-	-	ã	-	-	-	ɛ̃	ã	ɔ̃	œ̃
	ɔ̃	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	œ̃	-	-	-	-	-	-	-	-	-	-	-	-	-	-

As shown in (2), only a subset of the possible vowel combinations participate in VC. Some of the combinations simply do not occur (e.g. /ɔ, œ/+V), since /ɔ, œ/ are not allowed word finally. Sequences involving the nasal vowels /ɔ̃,œ̃/ in prevocalic position undergo liaison (cf. Rochette 1980: fn.24).

Dumas (1978) proposes that we are dealing with a mixed process of vowel elision and vowel coalescence. It seems that the melody of the lefthand input vowel is deleted if it is nonlow, while elsewhere both vowels are affected, giving rise to a mixture of them. However, he decides to account for these various changes by a unique (transformational) rule, which deletes the first input vowel and changes the second with respect to the features [long], [accent], [nasal], and [low]. Rochette (1980) argues against this approach, since Dumas characterizes VC by two distinct but nevertheless complementary rules of deletion and assimilation. Secondly, the fact that the output vowel is long (and accented) must be stated explicitly, as if it were an accident. Rochette therefore takes a different position, and formulates VC as a metrical process that percolates certain feature values of the segments involved to the node immediately dominating these segments. In her metrical framework, the rule of VC takes the following form:

(3)
$$\begin{bmatrix} +\text{syll} \\ (+\text{nas}) \\ (+\text{low}) \\ \vdots \end{bmatrix}^1 \begin{bmatrix} +\text{syll} \\ \vdots \end{bmatrix}^2 \longrightarrow \begin{matrix} [+\text{syll}]^2 \\ \vdots \\ ([+\text{nas}]^1) \\ ([+\text{low}]^2) \end{matrix}$$

Furthermore, she assumes a convention which deletes those values that have not undergone percolation. Hence, she proposes to regard the deletion aspect of VC as an immediate consequence of the percolation mechanism.

Only a subset of the features can undergo percolation. But it is not at all clear, a priori, why the features [+low] and [+nas] are transferred to the node immediately dominating the vowels and why other feature values are not. Rochette is aware of this problem, and therefore suggests an alternative view. She notices that the features which are retained from the lefthand vowel ([+low], [+nas]) are the 'marked' values: "[I]n the context of vowels in hiatus, these features are marked, in the sense that they are responsible for the perception of two distinct vowels. More explicitly, these features must be kept because of some kind of recuperability principle which enables us to decompose the contracted segment for the interpretation of the utterance" (p.42).

The latter view approximates to our view on the specific characteristics of VC. If Rochette's choice of marked values is compared with our choice of prespecified values in (4) below, the selected sets of features are almost identical.

In the remainder of this section we will analyze the Quebec French data within the nonlinear framework developed in the present thesis. The following feature specification will be assumed for the vowel system:

(4) a:

	i	e	ɛ	y	ø	œ	a	u	o	ɔ	ẽ	ã	ɔ̃	œ̃
high		-			-				-		-			
low			+			+	+			+		+	+	+
round				+	+	+		+	+	+			+	+
back				-	-	-								-
tense							-					-		
nasal											+	+	+	+

b: Redundancy rules:

[+low] → [-high]   [ ]   → [-round]
[ ]   → [+high]   [αround] → [αback]
[ ]   → [-low]
[ ]   → [+tense]

At first sight, it seems that we make the wrong predictions in quite a few cases, especially those where the left-hand vowel is [+round], because we wrongly predict that the output vowel will also be a round vowel. Hence, Quebec French seems to constitute a problem for the view that all prespecified feature values are preserved under VC. However, we will show that the seemingly nonstructure-preserving character of VC is the result of its interaction with the processes affecting vowels in word-final position.

Let us first of all determine the ordering between /ɛ/-laxing and VC. If it were assumed that VC is ordered after /ɛ/-laxing, we would wrongly predict that /ɛ/+V coalescence results in a long lax vowel, but diagram (2) reveals that the output of /ɛ/+V contraction is [+tense], except when the righthand vowel is [-tense]:

(5) a: elle était heureuse → [ɛ̄tœ̄rœ^{y}z] 'she was happy' (ɛ+ø)
b: j'était à la porte → [žetāpɔrt] 'I was at the door' (ɛ+a)

Under the assumption that VC takes place before /ɛ/-laxing, the forms in (5) are unproblematic. The second rule we have to consider is /a/-labialization. To account for the data in (6), we must stipulate that VC is extrinsically ordered after it, since otherwise we would predict that the output vowel is [-tense]:

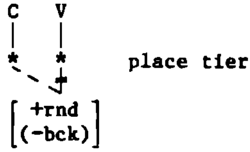
(6) il est pas usé → [jep^{u}œ̄ze] 'it is not worn out' (a+y)
ils sont pas heureux → [sɔp^{u}œ̄rø] 'they are not happy' (a+ø)

Confirmation for the claim that /a/-labialization precedes VC can be obtained from the data in (7) which show that /a/ agrees with the other round vowels in that it induces labialization of the preceding consonant:

(7) a: on l'a vu arriver → [ɔ̃llav^{y}ārive] 'one has seen him arrive'
elle veut les changer → [av^{y}ēšā̃že] 'she wants to change them'
c'est trop important → [setr^{u}ẽ̄pɔrtã] 'it is too important'
b: voilà les autres → [vl^{u}ɛ̄zɔ^{u}t] 'here are the others'
il a espéré → [j^{u}ɛ̄spere] 'he has hoped'
je suis pas inquiète → [šp^{u}ɛ̄kɛt] 'I am not worried'

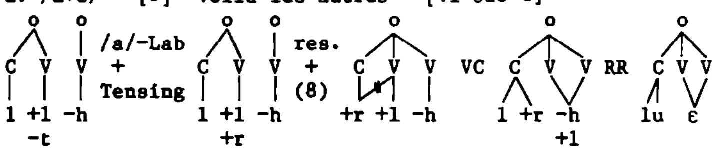
Hence, if we posit the Consonant-Labialization rule (8) below, ordered before VC, we can account for the apparent feature-changing character of coalescence:

(8) Consonant-Labialization[1]

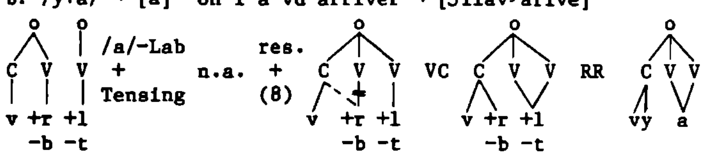


An immediate advantage of the approach outlined above is that the VC facts of Quebec French do not contradict our hypothesis concerning the general characteristics of VC (cf. chapter 2). Given this hypothesis, we predict that sequences in which one of the input vowels is specified as [+round] merge into a long [+round] vowel. However, Quebec forms in which the lefthand vowel is [+round] apparently refute this hypothesis, since the output is [-round] or [+round] depending on the specification of the right-hand vowel. If Consonant-Labialization applies before VC, we can account for this seemingly feature-changing character of coalescence. The following derivations in (9) show how the rules of /a/-Labialization, Consonant-Labialization and VC interact:

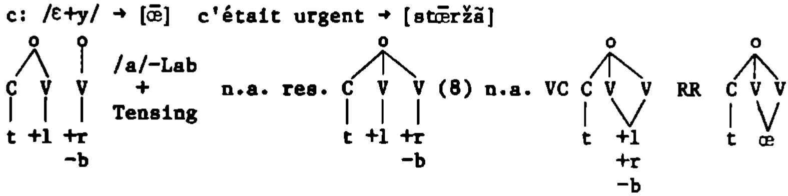
(9) a: /a+e/ → [ɛ̄] voilà les autres → [vl^{u}ɛ̄zɔ^{u}t]



b: /y+a/ → [ā] on l'a vu arriver → [ɔ̃llav^{y}ārive]



c: /ɛ+y/ → [œ̄] c'était urgent → [stœ̄ržã]

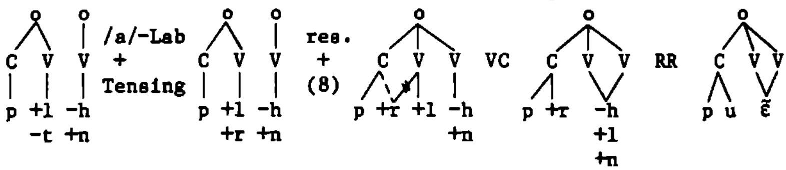


Let us finally turn to the fate of nasality under VC. Diagram (2) shows that [+nas] is preserved if at least one of the input vowels is nasal. The following data are illustrations:

(10) c'était impossible → [stɛ̃̄pɔsIb] 'it was impossible'
il est vraiment heureux → [jevrɛmœ̃̄rø] 'he is really happy'
je suis pas inquiète → [šp^{u}ɛ̃̄kɛt] 'I am not worried'

These facts show that the nasal features must be included in the structural description of the rule. We can achieve this by simply assuming that merger takes place between adjacent supralaryngeal nodes, since the supralaryngeal node is the first hierarchical node that dominates both the nasal features and the place features. In (11), the consequences of this approach are illustrated for a relatively simple example:

(11) /a+ẽ/ → [ε̃̃]   je suis pas inquiète → [sp^{u}ε̃̃kεt]



To summarize, we can conclude that the claim that VC accomplishes a merger of adjacent supralaryngeal nodes (section 4.4.2) is empirically supported by the facts of Quebec French, since the contraction rule preserves not only the place features but also the feature [+nas].

5.2. Korean and Rotuman

The notion of structure preservation is used ambiguously throughout the present study. We have introduced a distinction between structure preservation at the level of distinctive features (= micro level) and the phoneme level (= macro level). The latter is the more traditional interpretation which is employed in e.g. Kiparsky (1985) and Archangeli and Pulleyblank (1986). Kiparsky introduces conditions on which feature values may be marked lexically for certain segments. For example, in English and Russian the feature [voice] is distinctive for obstruents but not for sonorants. Kiparsky observes that we can express this by a marking condition which prohibits [voice] from being marked on sonorants in the lexicon. This condition plays a dual role, since it prohibits underlying voiceless sonorants, and voiceless sonorants arising from the application of lexical rules. Many examples have been brought forward in the literature that indicate that this condition is too strong (cf. Mohanan and Mohanan 1984, Archangeli and Pulleyblank 1986, among others). Below, we will add two more cases, from Korean and Rotuman, languages in which the feature [round] is nondistinctive in the class of front vowels underlyingly. However, the front round vowels /y, ø,œ/ arise in the course of the derivation by VC which are lexical rules in these languages. Korean and Rotuman therefore seem to be structure preserving at the level of distinctive features. In section 5.2.3 we will go into the relation between these two variants of structure preservation.

5.2.1 Korean

The following discussion of VC in Korean elaborates on the analysis by Sohn (1987) and is a continuation of the brief discussion in section 2.2. There are two issues concerning VC in Korean that deserve our attention. First, VC enlarges the vowel inventory of the language. Second, VC results either in a long vowel (V+V coalescence) or a short one (G+V coalescence). We will concentrate on these two aspects of the rule.

Sohn (1987) assumes an underlying eight-vowel system in which /ɨ/ is the default vowel. The vowel system proposed is the one represented in (12):

(12) Korean vowel system:

	i	e	æ	a	ə	o	u	ɨ
high		-			-	-		
low			+	+				
back	-	-	-					
round						+	+	

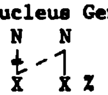
A sample of one set of data discussed by Sohn is given in (13). In these forms two identical vowels (cf. 13a) or a sequence of a vowel and the default vowel /ɨ/ (cf. 13b) optionally merge into a long vowel:

(13) a:	tah-a	[ta.a] ~ [tā]	'to arrive'
	cəs-ə	[cə.ə] ~ [cə̄]	'to whirl'
b:	nah-ɨmyən	[na.ɨmyən] ~ [nāmyən]	'to deliver (a baby)'
	is-ɨmyən	[i.ɨmyən] ~ [īmyən]	'to connect'

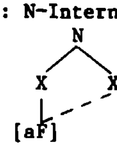
(where "." indicates a syllable boundary)

Sohn explains these facts by positing a postlexical rule of Nucleus Gemination whose output is subject to the OCP and Nucleus-Internal Spreading:

(14) a: Nucleus Gemination (postlexical)



b: N-Internal Spreading

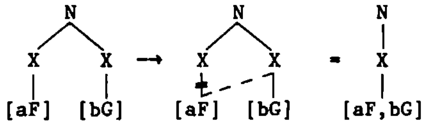


The second set of data consists of rising diphthongs such as those in (15):

(15) a:	kwemul ~ kömul	'monster'	b:	pyə	~ pe	'rice'
	weka ~ öka	'grandparent's'		p'yam	~ p'æm	'cheek'
	wisəŋ ~ üsəŋ	'hypocracy'		p'yocok	~ p'öcok	'sharp'
	wihəm ~ ühəm	'danger'		toyaci	~ twæci	'pig'

Sohn proposes Nucleus Degemination (16) to account for these data. It deletes a skeleton slot under a branching nucleus, and the floating feature matrix reassociates to an adjacent slot dominated by the same nucleus. Afterwards, these feature matrices merge into a short vowel:

(16) Nucleus Degemination

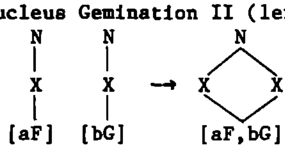


As a final case of VC consider the set of alternations given below:

(17) cu-ə	[cu.ə]	~ [cō][2]	'to give'
pe-ə	[pe.ə]	~ [pē]	'to cut'
kæ-ə	[kæ.ə]	~ [kǣ]	'to fold'
nə-eke	[nə.eke]	~ [nēke]	'to you'
na-eke	[na.eke]	~ [nǣke]	'to me'

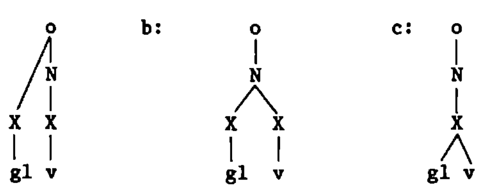
The lexical counterpart of Nucleus Gemination (14a) is posited to account for the set of data above. However, this rule of Nucleus Gemination deviates from (14a) as it includes the melody-internal change. Otherwise the output would yield a diphthong:

(18) Nucleus Gemination II (lexical)



Notice that at least four mechanisms are used to explain the Korean VC facts: (i) for identical vowels, Sohn invokes rule (14a) in conjunction with the OCP, (ii) in V+ɨ sequences rule (14a) and N-internal Spreading take place, (iii) for G+V sequences, Sohn appeals to Nucleus Degemination (16) which accomplishes a delinking, reassociation and merger of the melodic make-up, and (iv) for the heterosyllabic V+V sequences, Sohn employs rule (18), which achieves a change at the prosodic level (resyllabification) as well as a change in the melody (vowel merger). This variety of mechanisms invoked for what intuitively seems one change indicates that a generalization is being missed. Below, we will show that all the Korean facts find a straightforward account in the theory developed in this thesis. But first, we must devote some attention to the syllabification of rising diphthongs. We have available three ways of doing this, as is illustrated in (19) and, a priori, we cannot decide in favor of one of them:

(19) a:



where 'gl' is glide
'v' is vowel

Sohn (1987) argues that (19b) must be preferred for Korean on the basis of a word game and the absence of particular diphthongs. We will show, however, that representation (19c) is in fact preferable, since it renders the rule of Nucleus Degemination superfluous.

In the word game, heterosyllabic vowels or rising diphthongs are switched without affecting other segments in the syllable:

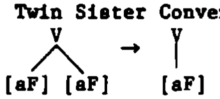
(20) a:	hobak	'pumpkin'	habok	*bahok
	bica	'visa'	baci	*cabi
b:	karyəŋ	'if'	kyəraŋ	*kəryaŋ
	hwicaŋ	'curtain'	hacwiŋ	*hwaciŋ

If the rising diphthongs are represented as in (19b), the switch of G+V as a unit is expected, according to Sohn (1987). However, the word-game facts can also be accounted for under (19c). Hence, the word game facts do not distinguish between (19b) and (19c).

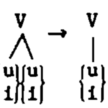
Given the underlying eight-vowel system and the underlying glides /y, w/, sixteen possible rising diphthongs are expected. However, Sohn observes that the following possibilities do not occur: *yi, *wu, *yɨ, *wɨ and *wo, and takes these gaps as evidence for representation (19b). The absence of *yi and *wu is considered an OCP effect, and the absence of G+ɨ diphthongs is caused by the default character of /ɨ/, and due to N-internal Spreading. Sohn does not account for the absence of *wo, but it seems plausible that this gap results from a syllable constraint which prohibits sequences of tautosyllabic labial vocoids. We will show that the remaining gaps can be accounted for under representation (19c).

First, the observation that *yi and *wu are impossible follows from Clements and Keyser's (1983) Twin Sister Convention, which merges two identical vowel matrices dominated by a single V-slot. For the sake of convenience we repeat this convention in (21a), and its effects in Korean in (21b):

(21) a: Twin Sister Convention



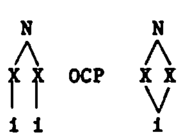
b:



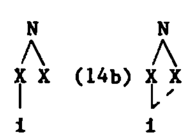
Our account of the absence of the diphthongs *yɨ and *wɨ crucially depends on the default character of /ɨ/. Given the fact that /ɨ/ is an empty V-slot underlyingly, the representations of /yɨ, wɨ/ are identical to the representations of the short vowels /i, u/, respectively, and by implication these representations will surface as [i, u].

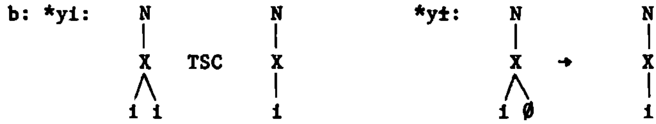
This may convey the impression that Sohn's proposal and ours are notational variants. However, the proposals make different predictions with respect to the length of the monophthongs that arise from the nonoccurring rising diphthongs. Sohn predicts that the monophthongs will be long (cf. 22a), while we predict they will be short, since the rising diphthongs are linked to a single V-slot (cf. 22b):

(22) a: *yi:



*yɨ:

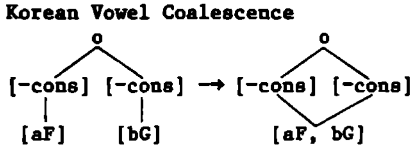




The data in (15) show that G+V coalescence results in short vowels. Hence, if the monophthongization of the nonoccurring rising diphthongs resulted in the long vowels /Ī, ū/ this would be peculiar indeed. Further confirmation for the correctness of our prediction can be obtained from the so-called /p/-irregular verbs in which the configuration wɨ appears underlyingly (cf. Sohn 1987:fn8). However, contrary to Sohn's expectations, this sequence surfaces as the short /u/. Hence, the /p/-irregular verbs provide independent evidence for the claim that rising diphthongs must be represented as in (19c).

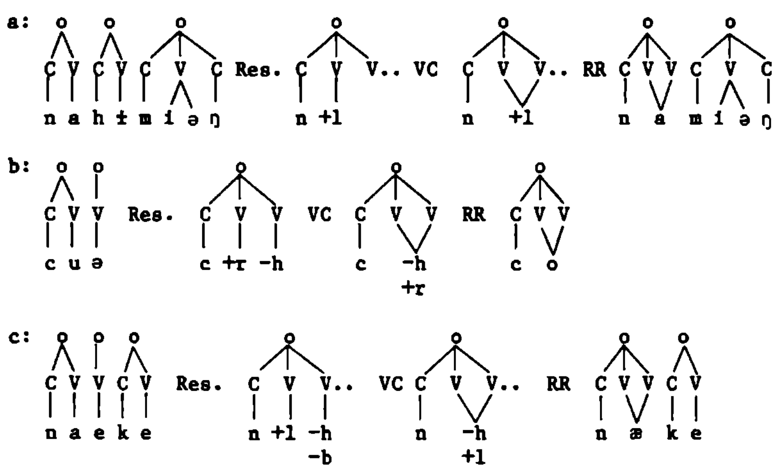
Let us finally turn to the description of the VC facts in (13), (15) and (17). On the assumption that VC is triggered by resyllabification (cf. section 2.2 for an argument based on Korean), we can account for all the facts by the general rule of VC in (23), which conforms to the universal format of chapter 2:

(23) Korean Vowel Coalescence



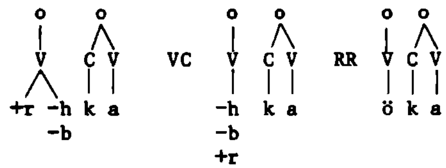
The data in (13) and (17) show the application of VC in its bare form: resyllabification with subsequent vowel merger. Some derivations are given in (24):

(24)

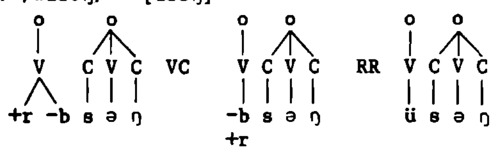


These derivations show that all prespecified feature values are preserved, and also that VC proper accomplishes a purely melody-internal change. Hence, the length of the output vowel is expected given our theory. But what about the forms in (15)? In these G+V sequences the output vowel is short. However, this is what we expect will happen, if rising diphthongs are represented as in (19c). The glide and vowel are associated to a single V-slot, and vowel fusion will merge the matrices of the input without affecting the skeleton:

(25) a: /weka/ → [öka]



b: /wisəŋ/ → [üsəŋ]



The discussion above clearly shows that all instances of vowel coalescence follow from a single rule of VC. One striking aspect of VC in Korean is the extension of the underlying vowel inventory. Given the fact that VC does not apply to words in sequence, the rule must be lexical, and therefore the Korean facts pose a problem for the version of structure preservation proposed in Kiparsky (1985). On the other hand, the appearance of the front rounded vowels is in keeping with the version of structure preservation which states that all lexically specified feature values, in Korean [-back] and [+round], must be retained. From this we can draw the conclusion that at least for Korean the latter version is the stronger one.

5.2.2 Rotuman

Rotuman is a Polynesian language spoken on the island of Rotuma some 200 miles N.N.W. of the Fiji islands. The language has been thoroughly described by Churchward (1940), and has attracted the attention of a considerable number of phonologists since (cf. Biggs 1965, Cairns 1976, McCarthy 1986, Odden 1986b, Besnier 1987). An important, though not yet fully understood, aspect of Rotuman morphology is the distinction between the complete and the incomplete phase which is marked by a complex set of vowel alternations. The alternations in (26) are of particular relevance to the present discussion:

(26) complete phase	incomplete phase	
mose	mös	'to sleep'
hoti	höt	'to embark'
futi	füt	'to pull'
pɔti (←pati)	pät	'scar'
läje (←laje)	läj	'coral'

Before we analyze these and other vowel alternations, we will first provide some background information. The use of the complete and incomplete phase is grammatically conditioned,as is shown in (27).

(27) a: famori feʔen — 'the people are zealous'
famör feʔeni — 'the zealous people'
b: famori ʔea — 'the people say'
famör ʔea — 'some people say'

Churchward (1940) distinguishes three types of vowels: the primary vowels /i, e, a, o, u/, the secondary vowels /ẹ, ọ, ä, ɔ/ and finally, the tertiary vowels /ü, ö/. The secondary and tertiary vowels are the result of a number of umlaut processes and of vowel coalescence, as a consequence of which their distribution is far more restricted than the distribution of the primary vowels. The latter class of vowels, for instance, can appear word-finally, while the others cannot. In addition, Churchward (1940:74) states that vowels have three lengths; the underlying vowels can be either short or long, whereas the tertiary vowels only appear with medium length. They mainly occur in superheavy syllables of the type (C)VVC, and are probably the result of a phonetic shortening rule, which reduces long vowels in closed syllables, as Odden (1986b) suggests. The above-mentioned umlauting processes in Rotuman are informally illustrated in (28):

(28) a: /a/ → [ɔ] / [$\overline{\text{+stress}}$] C_0 /i, u/
e.g. hɔ́gu 'to awake', tɔ́fi 'to sweep', sɔ́.i 'free'
b: /a/ → [ä] / [$\overline{\text{+stress}}$] C_0 /e/
e.g. lä́je 'coral', vä́ve 'fast', vä́.e 'to divide'
c: /e, o/ → [ẹ, ọ] / — C_0 /i, u/
e.g. sẹ́ru 'comb', fẹ́pi 'slow', fọ́lu 'three', móri 'orange'

On the assumption (made earlier in McCarthy 1986 and Besnier 1987) that the secondary and tertiary vowels are rule-governed allophones of the primary vowels, the Rotuman vowel system is a simple five-vowel system which can be characterized as in (29) within underspecification theory:

(29)

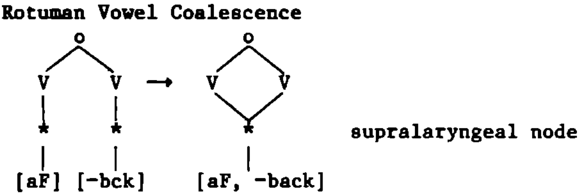
	i	e	a	o	u
high		-		-	
low			+		
round				+	+
back	-	-			

The forms in (26) exemplify the phenomenon of vowel coalescence. However, the vowel alternations due to the change from the complete phase into the incomplete phase are far more complex than can be inferred from these data alone. The additional data in (30) show that the construction of the incomplete phase also involve vowel elision (30a, b) and diphthongization (30c):

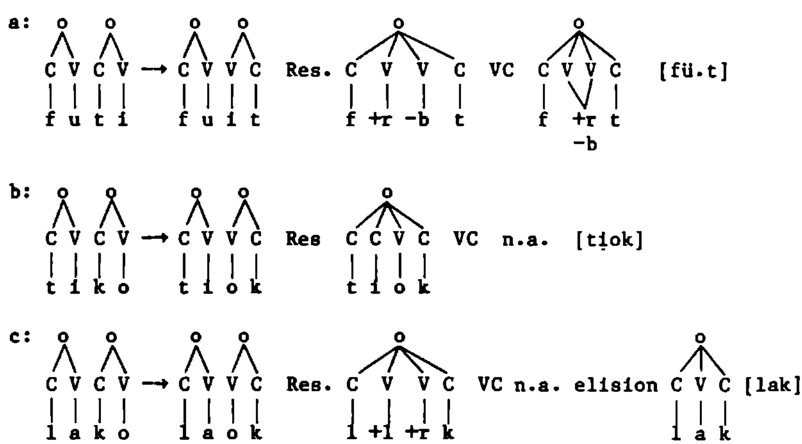
(30)	complete phase	incomplete phase	
a:	haga	hag	'to feed'
	tokiri	tokir	'to roll'
	hoto	hot	'to jump'
b:	ti?u	ti?	'big'
	fẹpi	fẹp	'slow'
	lako	lak	'to climb'
c:	tiko	tịok	'flesh'
	hosa	họas	'flower'
	pure	pụer	'to decide'
	pepa	pẹap	'paper'

The forms in (30c) contain an incomplete phase that is formed by a kind of metathesis which changes final CV syllables into VC syllables. Furthermore, the resulting vocalic hiatus is resolved by resyllabification. If the first vowel is less sonorous than the second, resyllabification will result in a diphthong,[3] and if the righthand input vowel is [-back], the vowels in hiatus merge into a tertiary vowel of medium length. Finally, all remaining cases undergo an elision rule which deletes the rightmost vowel. In (31) below, the process of Vowel Coalescence is formalized within the theory advanced here, and in (32) some derivations show the formation of the incomplete phase:

(31) Rotuman Vowel Coalescence



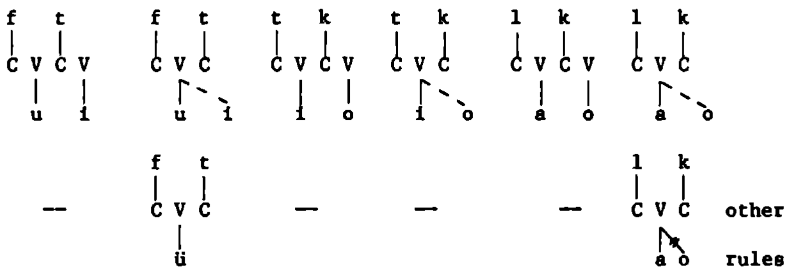
(32)



These derivations reveal that we need a number of language-specific statements to account for the set of alternations. We will not seek to minimize the number of rules, since this is beyond the scope of this thesis, but we can make out that the rule of VC in no respect deviates from the general pattern.

Recently, Rotuman has been analyzed by McCarthy (1986) and Besnier (1987) in a way different from our proposal. The major differences are the following: Both McCarthy (1986) and Besnier (1987) assume that Rotuman, like the Semitic languages, exhibit a segregation of vowels and consonants on separate planes. McCarthy's and Besnier's analyses differ, however, in the way the distinction between the complete and incomplete phase should be analyzed. McCarthy assumes that the complete phase is formed by adding a suffix consisting of an empty V-slot, while Besnier proposes to derive the incomplete phase by an elision rule which deletes the final V-slot. Details aside, the complete and incomplete phase are generated as follows:

(33)



[futi] [füt] [tiko] [ti̯ok] [lako] [lak]

At first sight, the analyses by McCarthy (1986) and Besnier (1987) explain the facts in a more elegant fashion than ours. However, Odden (1986b) presents a number of arguments against McCarthy's analysis, which, as far as we can see, also apply to Besnier's analysis. Odden notices that the evidence for the segregation of vowels and consonants is not very strong, since a metathesis rule can handle the facts equally well. Furthermore, the apparently unbounded character of vowel coalescence in forms like pulufi vs. pülüf 'stick', popori vs. pöpör 'suddenly' - for which McCarthy assumed that a single feature matrix is associated to two V-slots in the base in accordance with the OCP - can be covered for by a vowel harmony rule which propagates the feature [-back] from right to left if the vowels agree in rounding. Finally, Odden notes that McCarthy's analysis is empirically inadequate: it generates short diphthongs and short tertiary vowels, but the latter are of medium phonetic length. Hence, McCarthy has to assume some vowel lengthening rule, which, lengthening short vowels in heavy syllables, is less natural than a shortening rule which affects the length of long vowels in superheavy syllables. Moreover, the shortening rule is needed independently to account for the length alternations in forms like pupūi (complete phase) vs. pupui (incomplete phase) 'floor' and ʔā (c.p.) vs. ʔa (i.p) 'to bite'. With regard to the diphthongs in the incomplete phase, Churchward (1940) states that forms like momo̯as 'ripe' are pronounced "almost as two syllables". It is impossible to express this tendency in McCarthy's approach. In our analysis where metathesis activates resyllabification this tendency constitutes no problem if we assume that resyllabification is optional. On the basis of these shortcomings, the conclusion is inevitable that McCarthy's analysis of the Rotuman facts is inadequate.

We can observe that the underlying five-vowel system in (29) increases to a surface twelve-vowel system by the umlauting processes in (28) and VC in (31). Just as VC, umlaut is lexical, since it must take place before morphological reduplication, as illustrated in (34):

(34)	complete phase	incomplete phase		
	popore	pöpör	/RED+pore/	'suddenly'
	mɔmɔmi	mǎ̈mǎ̈m	/RED+mami/	'disgustingly sweet'
	sɔksɔkiro	sɔksɔkior	/RED+sakiro/	'to scrutinize'

The notion of structure preservation proposed by Kiparsky (1985) rules out an increase of the vowel inventory of the Rotuman type. However, if we assume structure-preservation at the level of distinctive features, the possibility of extending the vowel system is left open.

5.2.3 Structure preservation

We observed in chapter 4 that VC in the Attic dialect of Ancient Greek is structure preserving at both the distinctive feature and phoneme level, since neither the vowel inventory nor the distinctive feature inventory undergoes changes in the course of this process. In Korean and Rotuman, on the other hand, VC is nonstructure preserving at the phoneme level, whereas it is clearly structure preserving at the distinctive feature level. Nevertheless, there are lexical rules, such as voicing assimilation in English and Russian (cf. Kiparsky 1985), which are structure preserving at the phoneme level: in these languages sonorants neither act as triggers, nor as targets, or as blockers. Consequently, it is necessary to determine the relation between both types of structure preservation. A full account of this relationship requires further investigation, and all we hope to achieve here is to sketch the broad outline of what might lead to a solution.

Human languages only make use of a subset of the inventory of possible sounds and a subset of the features to distinguish them. In language after language a number of gaps in the sound pattern occur. The relevant question is whether all of these gaps are of the same nature. A survey of the gaps found in human languages reveals a striking difference among them. Many languages have besides the low back vowel /a/ only round vowels in the back series. However, there are languages having both front and back rounded vowels (e.g. Dutch, German, French, some dialects of Italian and postclassical Attic) or front and back low vowels (e.g. English, Quebec French, Korean), and they are very persistent in maintaining these oppositions. On the other hand, human languages are extremely unanimous in not allowing a lexical contrast between voiced and voiceless sonorants: to the best of our knowledge, there are no languages that exploit this as a lexical contrast. It belongs to the task of theoretical linguistics to provide a satisfactory explanation for this distinction and to consider its effects on the nature of phonological processes.

We will propose that the absence of a (derived) lexical contrast between voiced and voiceless sonorants is universal, while the variation among languages which allow or disallow a (derived) lexical contrast between front and back rounded vowels is language-specific.

If a language distinguishes voiced and voiceless obstruents, Universal Grammar determines that [+voice] is the lexical value, while [-voice] is the D-value for obstruents and [+voice] the R-value for sonorants. As a consequence, only [+voice] belongs to the underlying feature inventory. A lexical rule of voicing assimilation will therefore be necessarily structure preserving at the distinctive feature as well as the phoneme level, since the feature value involved in voicing assimilation, [+voice], is identical to the R-value for sonorants. Hence, lexical rules which create voiceless sonorants are ruled out by Universal Grammar.

On the other hand, Universal Grammar permits some slight variation with respect to the feature values which are taken as the lexical ones for languages having a five-vowel system /i, e, a, o, u/. For the sake of argument, three possible specifications are given in (35):

(35) a: Language A

	i	e	a	o	u
high		-	-	-	
back			+		
round				+	+

b: Language B

	i	e	a	o	u
high		-	-	-	
back	-	-			
round				+	+

c: Language C

	i	e	a	o	u
high		-		-	
low			+		
bck/rnd				+	+

Suppose these languages have a lexical rule of vowel coalescence. This rule will be structure preserving at the distinctive feature level in all three languages above, given the characteristics of VC argued for in this thesis. However, only the (35a) and (35c) languages will also be structure preserving at the phoneme level, while in the (35b) language the front rounded vowels arise by VC, as is illustrated in (36):

(36) a: Language A	b: Language B	c: Language C
e+a → a	e+a → e	e+a → a
e+o → o	e+o → ö	e+o → o
e+u → o	e+u → ö	e+u → o
i+u → u	i+u → ü	i+u → u
i+o → o	i+o → ö	i+o → o

Hence, the question whether a lexical rule is structure preserving at the phoneme level depends on the language-specific choice with respect to the features [back] and [round]. If [+back] and/or [+round] are taken as the lexically specified values in a particular language, a lexical rule will necessarily be structure preserving at the phoneme level, while a language in which on independent language-specific grounds [-back] and [+round] are the lexical values, a lexical rule may create segments which are [-back, +round], and, as a consequence, this rule will not be structure preserving at the phoneme level.

Thus, structure preservation at the distinctive feature level over-rules structure preservation at the phoneme level if and only if lexical rules generate sounds that fill in accidental feature cooccurrence gaps. Otherwise, structure preservation at the phoneme level will hold, as a rule.

The suggestion above entails an interesting prediction with respect to the evolution of postlexical processes. These processes are not necessarily structure preserving at the phoneme level according to Kiparsky (1985). Several cases can be found in the literature where postlexical rules result in sounds that are not allowed lexically. In Russian, for instance, voiceless sonorants arise postlexically, as observed by Hayes (1984) (cf. /bobr/ → [bopr̥] 'beaver'). It is predicted that these processes will behave differently if they are pushed into the lexical component. A postlexical rule which creates the front rounded vowels may evolve into a lexical rule with the same output, while a postlexical rule which creates voiceless obstruents and sonorants cannot become lexicalized without changing its very nature. We predict that this rule may evolve into a lexical rule, if and only if the sonorants will become nontriggers, nontargets and nonblockers, and hence fully transparent, since Universal Grammar determines that sonorants can only be specified as [+voice]. The difference between the lexical and postlexical voicing assimilation rules in Russian seems to confirm this prediction (cf.Hayes 1984 and Kiparsky 1985). However, a more definite statement concerning the evolution of nonstructure-preserving lexical and postlexical rules must await further and more thorough investigation.

5.3 Old Portuguese and Classical Sanskrit

Old Portuguese and Classical Sanskrit exemplify an interesting typological difference among the languages possessing a rule of VC. Old Portuguese belongs in one group together with Ancient Greek, while Classical Sanskrit belongs with Quebec French and Korean in another: in the former type of language high vowels do not participate in VC proper, as opposed to the latter. Below, it will turn out that the behavior of high vowels in hiatus confirms our hypothesis regarding the nonstructure changing nature of VC.

5.3.1 Old Portuguese

The resolution of vocalic hiatus in Old Portuguese was the main topic of Naro (1971) and De Haas (1987a). We will not go into the differences between these approaches, but instead focus on the interaction between vowel raising and vowel coalescence. Before discussing these processes, we will briefly outline the main properties of the Old Portuguese (henceforth OP) vowel system and the way it can be represented within the framework of underspecification theory.

OP exhibits a seven-vowel system consisting of the closed and half-closed vowels /i, e, o, u/ and the open and half-open vowels /ɛ, a, ɔ/. Within UT, this vowel system can be characterized as in (37):[4]

(37)

	i	e	ɛ	a	ɔ	o	u
high		-	-	-	-	-	
ATR			-	-	-		
round					+	+	+
back	-	-	-				

First, consider vowel raising, some examples of which are in (38). Parenthetical forms represent the Latin etyma of the OP forms:

(38) a:	mál-o	→ [mau]	~ [maw]	(mălum)	'bad'(1.decl.sg.)
	vol-ár	→ [vuar]	~ [vwar]	(vōlare)	'to fly'
	nέvo-a	→ [nɛvua]	~ [nɛvwa]	(nĕbŭlam)	'fog'
	kwál-es	→ [kwais]	~ [kways]	(quāles)	'which'(3.decl.pl.)
	venád-o	→ [viado]	~ [vyado]	(vēnātum)	'deer'
	ágel-a	→ [agia]	~ [agya]	(aquĭlam)	'eagle'
	dol-ér	→ [duer]	~ [dwer]	(dōlēre)	'to ache'(2.conj.)
	pejór-e	→ [pior]	~ [pyor]	(pējōrem)	'worse'(3.decl.sg.)
	gέmen-o	→ [gɛmiu]	~ [gɛmyu]	(gĕmĭnum)	'twin'
b:	ven-ír	→ [vīr]		(vēnīre)	'to come'
	sivíl-es	→ [sivīs]		(cīvīles)	'civil'
	núd-o	→ [nū]		(nūdum)	'naked'

According to earlier analyses by Nuñes (1945), Williams (1962) and Naro (1971), these forms involve the deletion of an intervocalic voiced consonant, followed by the raising of unstressed half-closed vowels. We can state the raising process as in (39):

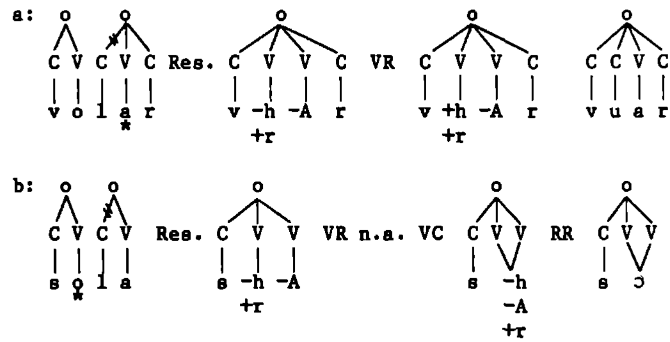
(39) Vowel Raising (VR)[5]

$$\begin{array}{lcl} & \text{V} & \\ & | & \\ \text{dorsal} & * & \longrightarrow [+\text{high}] \ \% \ \text{V} \overset{\sigma}{\wedge} \underline{\quad} \\ & | & \\ & \begin{bmatrix} -\text{high} \\ -\text{stress} \end{bmatrix} & \end{array}$$

OP also has a rule of vowel coalescence which merges two nonhigh vowels in hiatus into a long vowel. In (40), we present a number of relevant examples:

(40) a:	até agora	→ atɛ̄gora	'until now'
	owtra hɔra	→ owtrɔ̄ra	'another period'
b:	deza-óyta	→ dezɔ̄yta	'seventeen'
	sól-a	→ sɔ̄	'only'(fem.sg.)
	rad-ér	→ rɛ̄r	'to scrape'
	rέ-a	→ rɛ̄	'defendant'
c:	anéll-o	→ ɛ̄lo	'link'
	maór-e	→ mɔ̄r	'chief'

These data show that the output of VC is a long vowel whose quality is half-way between the half-closed and the open vowels. In other words, the output of VC is an articulatory compromise once again. To account for the difference between (38) and (40), we must assume that the rule of Vowel Raising precedes Vowel Coalescence. A closer look at the VC facts above reveals that this process does not crucially differ from the one proposed for the Attic dialect of Ancient Greek. Hence, the formalization of VC will be identical to its counterpart in Attic. In (41) below, a number of derivations are presented, illustrating the interaction between VR and VC:

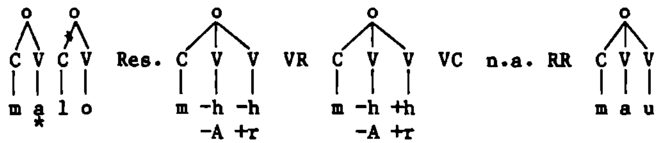
(41) a:


The account for the resolution of vocalic hiatus in OP presented here differs in a number of ways from that proposed in De Haas (1987a). In this earlier report, we assumed simultaneous spreading of the autosegments [high, low], [round, back] and [ATR] if they contain the dominant feature values [-low], [-ATR], [-back] or [+round]. However, this makes it difficult to retain the claim that assimilatory processes manipulate a single node in the feature geometry. In the present approach, VC accomplishes a merger of adjacent supralaryngeal nodes, and there is no need to weaken our single node view. Secondly, we had to assume a language-specific clustering of the features [back] and [round], although these refer to independent articulators, viz. the lips and the tongue body. Such a stipulation is superfluous in the present framework, since we have proposed to characterize VC as a process which involves the supralaryngeal tier, instead of the vocalic feature tiers. Furthermore, we had to add a stipulation regarding feature dominancy. However, we can dispense with this assumption, if we assume the specification of the vowel system given in (37) above. Finally, the rule of VC referred explicitlyto the class of nonhigh vowels to prevent the rule from applying to the output of VR. The forms in (42) show that the high vowels resulting from VR do indeed escape VC proper:

(42)	mál-o	→ mau	↛ *mɔ̄	'bad'
	vol-ár	→ vuar	↛ *vɔ̄r	'to fly'
	kwál-es	→ kwais	↛ *kwɛ̄s	'which'
	venád-o	→ viado	↛ *vɛ̄do	'deer'

The ill-formed items in (42) are properly excluded in the theory developed here. The underlying sequences in (42) are input to resyllabification, and as a consequence the unstressed half-closed vowels will become [+high]. VC cannot apply to the output of VR, because of the simple fact that only nondistinct vowels are allowed to merge. In the case of the vowel sequences in (42) one vowel is specified as [-high] while the other is specified as [+high]. Hence, the vowels are distinct and immune to VC. One simple and straightforward derivation is given as an illustration:

(43)



Summarizing, the present analysis of VC in OP is superior to the analysis proposed in De Haas (1987a) for a number of reasons. The most important is that we do not have to stipulate that VC is confined to nonhigh vowels. The fact that only nonhigh vowels are input to VC follows from the general format of VC which allows for the merger of adjacent supralaryngeal nodes if and only if they are nondistinct.

5.3.2 Classical Sanskrit

Whitney (1889) and Allen (1972) note that one of the main principles of vowel-to-vowel sandhi in Classical Sanskrit is that utterances are generally characterized by the absence of hiatus; i.e. there is a crucial difference between forms in isolation and sandhi forms. To a lesser extent, this principle also holds in Vedic, but in the classical language the resolution of vocalic hiatus is almost exceptionless.

At the surface the vowel system of Classical Sanskrit consists of the short vowels i, a, u, the long vowels ī, ē, ā, ō, ū, the syllabic liquids ṛ, ḷ, the diphthongs āy, āw and the nasalized approximants iṃ, aṃ, ṛṃ ..etc. However, the underlying vowel system is far less complex and it suffices to posit /i, a, u, ī, ā, ū/ underlyingly:

(44)

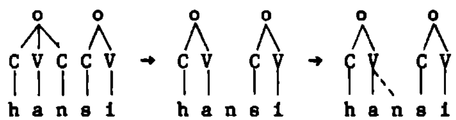
	i	a	u	ī	ā	ū
high		-			-	
back	-			-		
round			+			+

The long mid vowels [ē, ō] arise through a process of monophthongization of the diphthongs /ay, aw/. In addition, the syllabic liquids only appear in interconsonantal position, in word-initial position if a consonant follows, or in word-final position if a consonant precedes; elsewhere these liquids lose their syllabicity, as shown in (45):

(45) mṛdu asti → mṛdvasti 'it is delicate'
kartṛ asti → kartrasti 'there is a creator'
atha ṛṣiḥ → atharsiḥ 'then a seer'

Finally, the nasalized vowels arise through the loss of the word-final /n/ before a fricative. In autosegmental terms, we can describe this process as the loss of the timing slot and the reassociation of the nasal features onto the slot of the preceding vowel. A number of examples are given in (46). The derivation in (47) shows how this change can be handled in the present model:

(46) han-ṣi → haṃṣi 'you kill'
nṛns abhi → nṛṃsabhi → nṛṃzabhi → nṛṃrabhi 'towards the men'
dēvāns iha → dēvāṃṣiha → dēvāṃiha '(to) the gods here'

(47)  [haṃṣi]

Before we turn to the description of vowel coalescence, we will pay attention to the underlying representation of the long vowels [ē, ō]. We will argue that these vowels are secondary and stem from the diphthongs /ay, aw/.

Allen (1972:31-32) observes that "the Sanskrit e and o show certain structural parallellisms with the sequences ar and al, which comprise a short vowel a followed by a semivowel. This may be illustrated by a paradigm of the past participle, infinitive and s-aorist of the three verbs ji-, stu- and kṛ-:"

(48)

jita-	stuta-	kṛta-	(past participle)
jētum	stōtum	kartum	(infinitive)
ajayṣīt	astawṣīt	akārṣīt	(s-aorist)
'conquer'	'praise'	'cut'	

The assumption that [ē, ō] are still diphthongal has a grammatical advantage. In the second row the secondary form (guṇa) of the simple root vowels /i, u, ṛ/ shows up, that is, the simple vowels are strengthened by the insertion of a preceding /a/. In the third row the increased form (vṛddhi) shows up, which represents a further strengthening of the guṇa vowels by means of the lengthening of the previously inserted /a/.

A second argument for the claim that [ē, ō] are diphthongal underlyingly is that the internal sandhi alternation of [ē, ō] before consonants and [ay, aw] before vowels will become transparent:

(49)

a:	ajuhavam (1.sg.imperf.)	vs.	ajuhōt (3.sg.imperf.)	'sacrifice'
	asunavam		asunōt	'press out'
b:	jēṣyāmi		jayāmi	'conquer'
	cēṣyāmi		cayāmi	'gather'

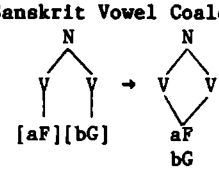
Before a vowel the second half of the diphthong will be resyllabified as the onset of the next syllable, which will prevent monophthongization.

Another argument for the underlying diphthongal nature of [ē, ō] can be found in the properties of vowel coalescence, which we will discuss below. First, we will provide a survey of the relevant facts which are taken from Whitney (1889) and Allen (1972):

(50)	a:	ca aprajaḥ	→ cāprajaḥ	'and he, offspringless'
		ati iva	→ atīva	'beyond like'
		su-uktam	→ sūktam	'well-spoken'
		na āsīt	→ nāsīt	'it was not'
	b:	tava indra	→ tavēndra	'for you, Indra' (voc.)
		hita upadēśaḥ	→ hitōpadēśaḥ	'friendly advice'
		atha ṛṣiḥ	→ atharṣiḥ	'then a seer'
	c:	rājā iva	→ rājēva	'like a king'
		sā ṛddhiḥ	→ sarddhiḥ	'prosperity'
	d:	iti āha	→ ityāha	'he spoke thus, so he said'
		yadi ētat	→ yadyētat	'if this'
		mṛdu asti	→ mṛdvasti	'it is delicate'
		kartṛ asti	→ kartrasti	'there is a creator'
	e:	tava ēva	→ tavāyva	'only yours'
		na ōjaḥ	→ nāwjaḥ	'(there is) no strength'
	f:	mama āyśvaryam	→ mamāyśvaryam	'my sovereignty'
		sā āwtsukyavatī	→ sāwtsukyavatī	'she is impatient'
	g:	indra ā ihi	→ indrēhi	'Indra, come' (voc.)
		upa ā ihi	→ upēhi	'approach'

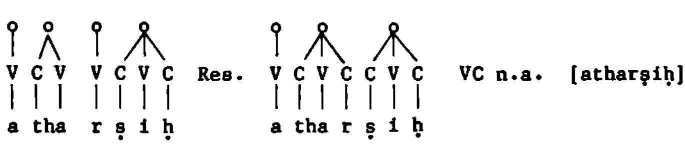
The data in (50a) need no elaboration, since both the quantity and quality of the vowels coalesced meet our expectations. More interesting are the vowel mergers in (50b). First, the form atharṣiḥ shows that the liquid loses its syllabicity. Hence, if we assume that resyllabification occurs whenever a hiatus arises, we can immediately account for this form. The remaining forms in (50b) can be explained similarly. An open vowel immediately followed by a closed vowel will undergo resyllabification and coalescence, resulting in the long mid vowels [ē, ō]. However, in the light of the remaining data in (50), we must assume that VC is confined to the domain of the syllable nucleus, and therefore the process of VC in Sanskrit takes the following form:

(51) Sanskrit Vowel Coalescence (postlexical)

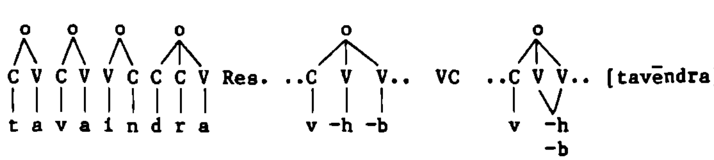


The process of VC is illustrated in (52) for a number of examples:

(52) a:



b:



```
c: o   o o o   o     o           o    o    o
   /\  /\ | /\  /|\   /|\  Res.   /|\  /\  /|\
  C V C V V C V C V V C V C  +  ..C V V C V C V V.  [hitōpadēśaḥ]
  | | | | | | | | | | | | |  VC   |  \/ | | |  \/
  h i t a u p a d a i ś a ḥ       t  -h p a d  -h
                                     +r        -b
```

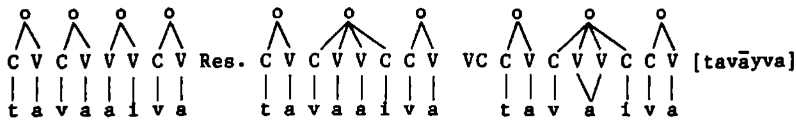
The derivation in (52c) is of particular importance, since it shows that VC is a postlexical rule which changes underlying as well as derived diphthongs into long mid vowels.

In (50c), the first input word ends in a long open vowel. Allen (1972:37) states that "the process of derivation must include in addition a shortening of the final vowel if in the basic form it is long; and this must be applied before the reduction of the initial vowel to a semivowel." Put in our terms, vowel shortening must take place before resyllabification, since otherwise we would derive the diphthongs [āy, āw] which do not undergo monophthongization. If this analysis is correct, the derivation of the forms in (50c) proceeds along the same lines as for those described in (52).

Let us now turn to the forms in (50d). We can observe, just as we did for Ancient Greek, that high vowels in hiatus do not behave like non-high ones. Sequences of open and closed vowels merge into a long vowel, while sequences of closed plus open vowels do not. The examples in (50d) show that the hiatus is resolved by resyllabification, but that VC fails to apply. In our discussion of Korean, we saw that a sequence of a closed plus open vowel can be syllabified in three different ways: under the nucleus, producing a rising diphthong (cf. 19b, c above), or as onset and nucleus respectively (cf. 19a). Allen (1972:35), following the old Indian grammarians, states that such a closed vowel "appears in sandhi in a reduced, nonsyllabic semivocalic form", for which the grammarians introduced the notion 'ksaipra' sandhi. As a consequence, the high vowel will be syllabified into the onset, and VC will be left unactivated, as depicted in (53):

```
(53) o   o   o   o          o   o     o
     /\  /\  |  /|\         /\  /|\   /|\
     C V C V V C C V  Res.  C V C C V C C V  VC  n.a. [mr̥dvasti]
     | | | | | | | |        | | | | | | | |
     m r d u a s t i        m r d u a s t i
```

The set of data in (50e) and to a lesser degree those in (50f) are in more than one respect important to the present discussion. First, they provide additional evidence for the claim that [ē, ō] represent the diphthongs /ay, aw/, and furthermore they confirm our claim that VC is confined to the syllable nucleus. If [ē, ō] represented long mid vowels underlyingly, the output of a+ē and a+ō contraction would be anomalous, all the more so since both a+ī and a+ū contraction result in long mid vowels. If a+ē can produce the diphthong [āy], we expect that a+ī will do likewise. However, the data in (50) show that this prediction is false. If, on the other hand, we assume that [ē, ō] represent the diphthongs /ay, aw/, the diphthongal character of the output is unproblematic, since contractions of a+ay and a+aw into [āy, āw] seem very natural. The remaining question is why the diphthongs /ay, aw/ become monophthongized by VC, while /āy, āw/ in (50e, f) retain their diphthongal character. The solution is rather simple if we assume that VC is confined to the syllable nucleus. In Sanskrit, and in most (if not all) human languages, the nucleus can maximally contain two segments. Hence, in (50e, f) the off-glides will be syllabified under the syllable coda, and, as a consequence, escape VC. The following derivation shows this aspect of resyllabification most clearly:

(54) 

It will be evident from this discussion that the claim that resyllabification feeds VC is crucial. This assumption enables us to state VC in the way we did, without any conditions imposed on the quality and quantity of the input vowels. Had we assumed that VC takes heterosyllabic vowels in hiatus as its input, we would heve been forced to include all kinds of conditions in the structural description of the rule, viz. (i) the first input vowel must be [-high], (ii) the first input vowel must be [-long], and (iii) the first input vowel may be [+high] if the second input vowel is identical to the first. Furthermore, an independent rule of resyllabification is necessary anyway, since otherwise forms like sarddhiḥ and kartrasti, in which the liquid was syllabic underlyingly are left accounted for. Hence, the simplest grammar of Classical Sanskrit is the one in which resyllabification precedes VC.

Finally, in (50g) we find three vowels in hiatus. The first word which ends in a short /a/ is followed by the preposition ā which in turn is followed by a word beginning with a high vowel. Whitney (1889) and Allen (1972) observe that VC of a+ā must precede the contraction involving the word-initial high vowel, since otherwise we would wrongly derive the diphthongs [āy, āw], as is shown in (55):

(55) a: [indra [ā ihi]]	b: [[indra ā] ihi]	
		first cycle:
[a+i]	[—]	vowel shortening
[ē]	[ā]	VC
		second cycle:
[—]	[a + i]	vowel shortening
[āy]	[ē]	VC
*[indrāyhi]	[indrēhi]	

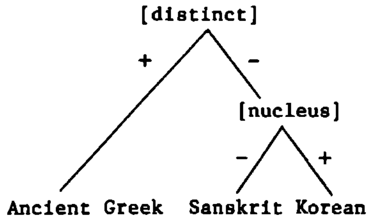
These derivations reveal that resyllabification and VC must proceed from left to right. Given the postlexical status of VC we cannot appeal to the cycle to ensure that VC will apply in this direction, since postlexical rules are noncyclic by definition (cf. Kiparsky 1982). The solution therefore has to be found elsewhere.

We can account for the forms in (50g) if we assume that the preposition ā behaves like an enclitic which is added to the preceding word in the lexical component of the grammar. As vocalic hiatus is not allowed word-internally and word-externally, it is possible to resolve the hiatus between a and ā by resyllabification in the lexicon. Postlexically then, the long /ā/ is input to vowel shortening and resyllabification, so that VC will be able to produce the correct output. In this analysis, the left to right application of VC is an immediate consequence of the organization of the grammar, that is, the ordering of lexical rules before postlexical rules as a theoretical axiom.

The preceding discussion reveals that the high vowels /i, u/ participate in VC in Classical Sanskrit, while they fail to do so in Old Portuguese. We saw that the high and nonhigh vowels in OP were made distinct prior to the application of VC by the independent process of Vowel Raising. However, Sanskrit lacks a rule that prior to VC inserts [+high] or mentions it in its structural description. The high and nonhigh vowels are therefore still nondistinct when VC arrives and the rule is thus expected to apply freely. The observation that only a subset of the possible combinations of open and closed vowel participate in VC is related to the syllabification of the high vowels. If they are syllabified under the nucleus, they fulfill the structural requirements of VC, but if they are syllabified under the onset or coda, VC will not have a chance to apply.

The research into the properties of VC has uncovered an interesting typological difference between the VC languages. OP is included in the group of languages in which high vowels do not undergo VC, while Classical Sanskrit belongs to the VC languages in which VC affects both high and nonhigh vowels. In the latter type of language we observed an additional subdivision. The languages of this group seem to differ with respect to the domain in which VC takes place. Two main reasons have been adduced for these divisions. The first concerns the segmental level and stems from the notion of distinctness. If high and nonhigh vowels are distinct, VC cannot affect both high and nonhigh vowels in sequence (e.g. Ancient Greek, OP), and if they are nondistinct at the relevant stage in the derivation, VC can take both sets of vowels as its input (e.g. Korean, Rotuman, Classical Sanskrit). The second reason concerns the suprasegmental level and is related to the position of the high vowels in the syllable. We can draw a distinction between languages in which prevocalic high vowels are syllabified as onsets (e.g. Classical Sanskrit) and languages in which they are syllabified as nuclei (e.g. Korean). Hence, the participation of high vowels in hiatus seems to be determined by two parameters: distinctness and position in the syllable. These two parameters give rise to three types of VC languages, schematically described in (56):

(56)



In conclusion, the introduction of the distinctness and nucleus parameters enables us to account for the differences among the VC languages in an illuminating way.

5.4 Recapitulation

The aim of the preceding sections was twofold. First, we have examined a number of VC languages with the intention of verifying the hypotheses regarding the nature of VC which we developed in chapter 2 and elaborated in chapter 4 for Ancient Greek. Furthermore, the choice of the languages discussed here is largely determined by the fact that they provide insight in and evidence for our theory that could not be obtained from VC in Ancient Greek. In section 5.1 we discussed Quebec French, a language providing empirical support for the claim that VC involves the merger of nondistinct supralaryngeal nodes in the feature geometry. Next, we paid attention to Korean and Rotuman, which support the claim that VC is nonfeature-changing, that is, all prespecified feature values are preserved. By making this claim, we predict that VC is basically nonstructure preserving in the traditional sense. The fact that in both languages the nonunderlying front rounded vowels /ü, ö, œ/ are created by VC, shows that this prediction is borne out by the facts. Finally, we have included Old Portuguese and Classical Sanskrit among our sample languages, because they reveal an important difference between the behavior of high vowels in hiatus. In chapter 2 we took the strong position that VC can only merge nondistinct segments. In OP high and nonhigh vowels are made distinct by Vowel Raising. Hence, we expect that a sequence of high and nonhigh vowel will be immune to VC. The facts of OP show that this prediction is correct. Given the fact that these vowels became distinct by rule, we expect to find languages lacking such a P-rule, in which high vowels will in fact undergo VC. Classical Sanskrit appeared to be such a language and the discussion in 5.3.2 proved that our prediction was correct.

5.5 Apparent VC languages

In this section we will discuss a number of languages that are included among the VC languages in the literature. Some of these languages apparently present problems for the theory advanced in this thesis, since the processes involved contradict one or more of the diagnostic criteria which VC must satisfy. We will argue that the vowel mergers in these languages do not result from a process of VC, but are the by-product of independently motivated processes. Once again, the analyses presented are necessarily sketchy. However, in each case, we will mention a number of references consulted, which provide a more detailed account of the language, and phenomena at hand.

5.5.1 Kasem nominals

The West African language Kasem which is spoken on both sides of the northern border of Ghana and Burkina Faso, figured prominently in rule-ordering and rule-application debates in the late seventies (cf. Chomsky and Halle 1968, Anderson (1969), Phelps 1975b, 1979 and Halle 1978). The main sources for Kasem are Callow (1965a, b) and the analysis to be presented here is basically the same as that proposed in De Haas (1988a).

Kasem is a tone language and it has a ten-vowel system consisting of two harmonic sets based upon the feature [ATR]. If we ignore this distinction, however, we can represent the five-vowel system as in (57):

(57)	i	e	a	o	u
high		-	-	-	
back	-	-			
round				+	+

The Kasem nominals can roughly be divided into the five noun classes in (58) below, and this subdivision is - like in many related African languages - based on the various forms of the singular and plural suffixes:

(58) class	singular	plural	
A	čid-u	čid-a	'witch'
B	nakw-i	nakw-a	'elder'
C	fal-a	fal-i	'white man'
D	čud-u	čud-du	'neighbor'
E	sug-u	su-ni	'guinea hen'

The class E form in (58) exemplifies the first relevant phonological rule of Kasem. If a stem ends in a velar consonant, then it will show up in the singular only, as the additional data in (59) indicate:

(59) class	singular	plural		
C	diga	di	(←dig-i)	'room'
	zuŋa	zwi	(←zuŋ-i)	'calabash'
	čoŋa	čwe	(←čoŋ-i)	'path'
D	tasugu	tasudu	(←tasug-du)	'granary cover'
	fogo	fwadu	(←foag-du)	'die, dice'

Besides these facts, Kasem distinguishes class D nominals that show a vowel length alternation. The examples in (60) show that the stem vowel is shortened in the singular:

(60) class	singular	plural	
D	piu	pīdu	'mountain'
	tiu	tīdu	'piece of soil'

Let us now examine the examples in (61) below, which illustrate two additional processes. First, we can observe that round vowels alternate with the labial glide in the plural. Furthermore, we can observe that in a sequence of two vowels agreeing in backness and roundness, the suffix vowel is deleted:

(61) class	singular		plural		
A	tu	(←tu-u)	twa	(←tu-a)	'corpse'
	buko	(←buko-u)	bukwa	(←buko-a)	'daughter'
B	ni	(←ni-i)	nia	(←ni-a)	'mouth'
	si	(←si-i)	sia	(←si-a)	'bambarra beans'
C	pia	(←pi-a)	pi	(←pi-i)	'yam'
	pia	(←pe-a)	pe	(←pe-i)	'sheep'
	kua	(←ku-a)	kwi	(←ku-i)	'bone'
F	sua	(←su-a)	swa	(←su-a)	'guinea-hen chick'

Finally, the data in (62) illustrate a phenomenon which affects the segmental make-up of two vowels in hiatus:

(62) class	singular		plural		
B	zwe	(←zwa-i)	zwa	(←zwa-a)	'ear'
	čwe	(←čwa-i)	čwa	(←čwa-a)	'liver'
C	yua	(←yo-a)	ywe	(←yo-i)	'hair'
	pia	(←pe-a)	pe	(←pe-i)	'sheep'
D	sio	(←sē-u)	sēdu	(←sē-du)	'shea-nut'
	fogo	(←foag-u)	fwadu	(←foag-du)	'die, dice'

At first sight, the changes above seem fairly complex. The first involves the low vowel /a/ preceding a high vowel. In the output the a+i seem to have been merged into a short mid vowel. The second change involves a kind of height metathesis. The left-hand mid vowel is raised to high and the right-hand high vowel is lowered to mid. These forms brought Chomsky and Halle (1968), Halle (1978), De Haas (1987a), and Yip (1988) to posit a process of vowel contraction. However, Phelps (1975b, 1979) argues that no independent rule of vowel contraction is actually at work here. She posits a special kind of metathesis rule to account for the changes in (62) above, viz. Vowel Height Exchange (63):

(63) Vowel Height Exchange

$$\begin{array}{ccccc} \begin{bmatrix}+\text{syll}\\ -\text{high}\end{bmatrix} & [+\text{syll}] & \rightarrow & \left\{\begin{matrix}\emptyset \;/\; [\overline{+\text{low}}] \\ [+\text{high}]\end{matrix}\right\} & [-\text{high}] \\ 1 & 2 & & 1 & 2 \end{array}$$

(Phelps 1979:37)

Although disagreeing in details, De Haas (1988a) reached essentially the same conclusion: the apparent vowel mergers are the result of the interaction of independently motivated processes, and there is therefore no need for a rule of vowel contraction.[6] Below, we will present a rough outline of the considerations that led to this conclusion.

For a better understanding of the discussion, we have to make explicit one assumption of the proposal in De Haas (1988a): inflectional suffixes fall into two separate classes: (i) suffixes that are linked to a timing slot (timed suffixes) and (ii) suffixes that are not associated to a timing point (untimed suffixes). The main reason for this classification depends on properties of processes such as velar elision and glide formation. These processes seem to be restricted to the plural. The relevant question is whether the alternations are caused by an idiosyncratic property of some suffixes, or alternatively are caused by idiosyncratic conditions imposed on individual phonological rules. The observation that both processes require the same morphological condition: [+plural], and the further observation that these rules apply in concert to particular noun classes, while the singulars never undergo them, indicates that the alternations result from an idiosyncratic property of particular suffixes. The classification in (64) will be assumed without further discussion (cf. De Haas 1988a for more details):

(64)

	UNTIMED	TIMED
	sg.	pl.
A	-u	-a
B	-i	-a
C	-a	-i
D	-u	-du
E	-u	-ni
F	-a	-a

The first relevant rule is that of Velar Elision (65). Given the classification in (64) we do not have to include [+plural] into the structural description of this rule, but we can simply state it as the deletion of a velar consonant before a timing slot:

(65) Velar Elision

$$\begin{array}{ll} \begin{array}{c} C \\ | \\ \begin{bmatrix} -\text{ant} \\ -\text{cor} \end{bmatrix} \end{array} \rightarrow \emptyset \; / \; \text{—} \; X & \begin{array}{l} \text{CV tier} \\ \\ \text{place tier} \end{array} \end{array}$$

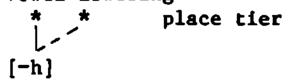
The round vowel-glide alternations in (59) indicate that a rule of resyllabification is at work. This rule seems to be idiosyncratically conditioned because /u, o/ are changed into labial glides, while /i, e/ are not changed into their corresponding palatal glide. If this is taken into account, we can state resyllabification as in (66):

(66) Resyllabification

$$\begin{array}{cc} \begin{array}{c} o \\ | \\ V \\ | \\ [+r] \end{array} \; \begin{array}{c} o \\ | \\ V \\ \\ \end{array} & \rightarrow \quad \begin{array}{c} o \\ \diagup \;\; \diagdown \\ C \qquad V \\ | \qquad\;\; \\ [+r] \qquad\;\; \end{array} \end{array}$$

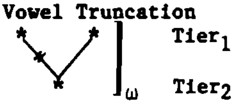
The data in (62) seem to require some special treatment. However, underspecification theory enables us to explain these data with a simple assimilation or feature-spreading rule: Vowel Lowering (67), spreading [-high] from left to right:

(67) Vowel Lowering



For this analysis to work, one additional language-specific rule must be posited to account for the length alternations and the raising of prevocalic mid vowels to high in (60) to (62). We want to propose that both changes are instances of one and the same process of Vowel Truncation which changes many-to-one into one-to-one associations. Vowel Truncation (68) is restricted to configurations at the righthand edge, indicated here by the inclusion of the word boundary:

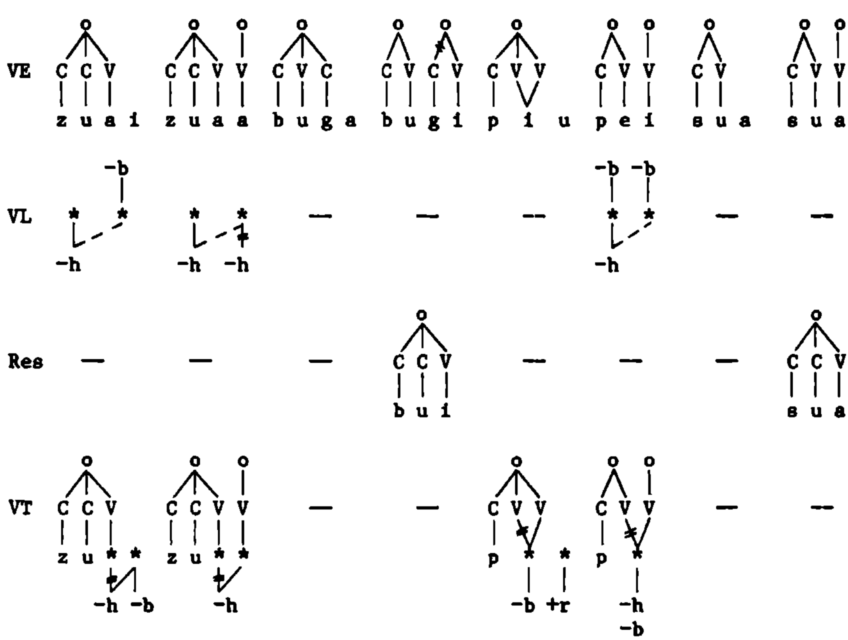
(68) Vowel Truncation



Vowel Truncation has two expansions. The first subrule applies to long vowels like those in (60), while the second applies to partial geminates like those arising from Vowel Lowering.

All other mechanisms in this analysis are independently required. First, we have to invoke the Obligatory Contour Principle which merges identical features or feature complexes. Furthermore, we will assume that empty slots disappear by means of the universal Stray Erasure Convention. Finally, we must assume an Affix Timing mechanism which associates untimed melodies to available slots in the CV skeleton. We will wind up this discussion with a number of sample derivations:

(69) /zwa-i/ /zwa-a/ /bug-a/ /bug-i/ /pĪ-u/ /pe-i/ /su-a/ /su-a/



```
       o       o       o   o            o  o     o       o  o
Tim.  /|\     /|\     /\  /\            /\ |     /\      /\ |
+     C C V   C C V   C V C V     —     C V V    C V     C V V     —
SEC   | | :   | | |   | | | :           | | :    | |     | | :
      z u e   z u a   b u g a           p i u    p e     s u a
      [zwe]   [zwa]   [buga]    [bwi]   [piu]    [pe]    [sua]   [swa]
```

Let us summarize briefly. The preceding discussion draws heavily upon the discussion of Kasem nominals in De Haas (1988a). It turns out that the vowel mergers observed can be derived by Vowel Lowering and Vowel Truncation, and these two processes render superfluous a special rule of vowel contraction. It must be clear, though, that this analysis can be maintained only if underspecification is assumed, since in that case Vowel Truncation gives rise to empty vowel slots that can be deleted by the universal Stray Erasure Convention. If segments are fully specified, forms like [zwe] and [fogo] cannot be derived, and we would wrongly predict *[zwae] and *[fogao]. Hence, an additional process of a+e and a+o contraction would be needed to account for the facts. Thus, the theory of underspecification allows us to considerably simplify the grammar of Kasem.

5.5.2 Kikuyu

In Kikuyu, an East African language spoken in Kenya, vowel fusion and diphthongization are highly productive processes. They merge vowel sequences into a heavy syllable, and apply both word-internally and word-externally. Our main sources for Kikuyu are Armstrong (1940) and Sharp (1960). Armstrong (1940:16) provides the following informal characterization of the resolution of vocalic hiatus. "In all cases in which two vowel sounds of adjacent vowels refuse to exist side by side in context, the result is a monosyllabic vowel, either simple or diphthongal. Examples may be divided into three types according to the nature of the result:

1. Types in which the resulting monosyllabic vowel is simple, and different in quality from either the final of the first or the initial of the second.
2. Types in which the resulting vowel is diphthongal. Examples of this type fall into three classes:
   a: those in which both elements of the context diphthong differ from the final and the initial vowels of the non-context form of the adjacent words.
   b: those in which the first element of the context diphthong differs from the final vowel of the first word, as pronounced in isolation.
   c: those in which the second element of the context diphthong differs from the initial vowel of the second word, as pronounced in isolation.
3. Types in which the resulting monosyllabic vowel has the quality either of the final vowel of the first word or of the initial vowel of the second".

In (70) below, we present a survey of the intriguing facts of Kikuyu, by and large following Armstrong's classification:

(70) a:	ma-akirɛ	→ mākirɛ	'they built (today)'
	a-inɛrɛ	→ ai̯nɛrɛ	'he danced, sang (today)'
	mekaŋa ena	→ mekaŋɛ̄na	'four bracelets'
	a-ɛndiriɛ	→ ɛ̄ndiri̯ɛ	'he sold'
	kogẹa na-okare	→ kogẹa nɔ̄kare	'to be stingy'
	a-ɔnirɛ	→ ɔ̄nirɛ	'he saw'
b:	mocɛ̄rɛ-ogo	→ mocɛ̄rẹɔgo	'this rice'
	mehēndɔ-ena	→ mehēndọɛna	'four ropes'
	njɔrɔgɛ-uma	→ njɔrɔgẹɔi̯ma	'Njoroge, come out'
	mbɔgɔ-uma	→ mbɔgɔi̯ma	'Mbogo, come out'
	mbura-ura	→ mburɔi̯ra	'rain, come down'
c:	kemɛɲɛ-atere	→ kemɛɲẹatere	'now understand this'
	mụērɛ-ɔkɛ	→ mụērẹɔkɛ	'tell him to come'
	negụɔ-adɔ̄mɛ	→ negọadɔ̄mɛ	'so that he may read'
d:	ko-ɔha	→ kọɔha	'to tie up'
	ko-uneka	→ kūneka	'to break'
	nẹare-uma	→ nẹarẹuma	'he will come out'
	ne-ota	→ nẹota	'it's a bow'
e:	nɔ̄mbɛ-emo	→ nɔ̄mbɛ̄mo	'one cow'
	ohɔrɔ-omo	→ ohɔrɔ̄mo	'one event'

(g and d indicate the voiced velar and the voiced alveolar fricatives)

We observe that sequences of a low vowel plus a nonhigh vowel merge into a long vowel, while a diphthong arises if the right input vowel is high. When the lefthand input vowel belongs to the half-open series, a metathesis of height seems to take place, by which the left input vowel undergoes raising to the half-closed series and the righthand vowel is lowered to the open series, or remains open. This metathesis fails to occur,however, if the mid vowels agree in backness and roundness, since in that case merger into a long half-open vowel occurs. Finally, if the left input vowel is /e/ or /o/, this vowel loses its syllabicity without affecting the quality of its neighbor.

Especially the a+V examples suggest that we are dealing with a case of vowel coalescence. However, assuming an independent rule of this type raises some serious problems for the theory advanced here. The most important is why sequences of a+V merge, while sequences of ɛ+V and ɔ+V in general do not. As far as we can see, there is no way to ensure that the latter sequences are distinct, while at the same time a+V sequences are still nondistinct at the stage of the derivation where VC becomes applicable. Furthermore, the rule of vowel coalescence would have some curious properties. First, we would have to stipulate that the spreading of [-ATR] would proceed from left to right, and second, we would have to assume that the spreading of [+round] or [-back] proceeds in the opposite direction just in case the preceding vowel is /a/, and that the same features do not spread in all remaining cases. This leaves us with a very unsatisfactory situation. Therefore, we will suggest here an alternative solution for the resolution of vocalic hiatus in Kikuyu which completely lacks a rule of coalescence. One thing must be clear, though, from the data in (70): Kikuyu does not permit vowels in hiatus. The mechanism employed to resolve such a hiatus is resyllabification. Hence, in this respect Kikuyu does not differ from the regular VC languages and provides additional confirmation for the claim that the main mechanism for avoiding vocalic hiatus is resyllabification.

Before continuing our analysis of the forms in (70), we will take a closer look at a number of other phonological rules of Kikuyu. First, consider its very restricted type of vowel harmony. If the stem contains [ɛ, ɔ], the vowel linking the suffix will also be [ɛ, ɔ]. Elsewhere, the linking vowel is either [e] or [o], as is shown in (71):

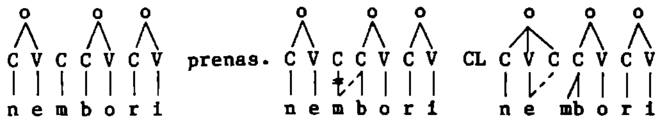
(71) a:	it-ek-a	'be poured away'
	hat-ek-a	'squeeze'
	hĩŋg-ok-a	'open'(intr.)
	gar-ok-a	'turn around'(intr.)
b:	ɔn-ɛk-a	'be seen, appear'
	mɛnɛ̃nd-ɛk-a	'be smashed to smithereens'
	cɔn-ɔk-a	'be ashamed'
	hɔn-ɔk-a	'escape from'

These data seem to involve the spreading of the harmonic feature [ATR] from the stem vowels [ɛ,ɔ] to the linking vowel. However, in the case of two vowels in hiatus a similar change takes place: if the first input vowel is /ɛ, a, ɔ/ the feature [ATR] spreads to the righthand vowel. There is at least one difference, though: in the case of non-adjacent vowels the vowel /a/ does not trigger spreading, while it does for adjacent vowels. We do not have an explanation for this difference, but it probably stems from the fact that vowel harmony in (71) is lexicalized, since it only applies to a small number of affixes, while it is postlexical in (70).[7] The observation that particular vowels are neutral or opaque with respect to lexical vowel harmony processes, while, in the same language, they participate in the postlexical variant of the same rule is not completely unprecedented (cf. Akan vowel harmony described in Clements 1981). Hence, we will assume that a rule of [ATR]-spreading is involved in the data in (70).

The second process we want to draw attention to is compensatory lengthening. Armstrong (1940) states that short vowels undergo lengthening, if the following word belongs to what she calls the 'nasal group'. A number of examples are given in (72):

(72) a:	nē-mbori	'it's a goat'	b:	ne-mōndo	'it's a man'
	nē-njati	'it's a star'		ne-cūva	'it's a bottle'
	tī-ŋgūo	'it's not a hippo'		ti-mōndo	'it's not a man'
	tī-mbori	'it's not a goat'		ti-cūva	'it's not a bottle'

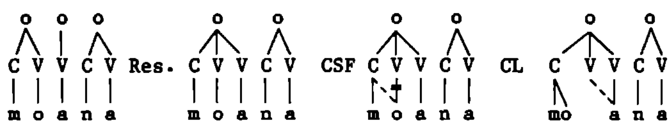
Clements (1986) and Sagey (1986a, b) describe similar facts in LuGanda and Kinyarwanda, respectively. In all these cases the nasal plus obstruent cluster is changed into a prenasalized stop with concomitant lengthening of the preceding vowel. This type of compensatory lengthening is illustrated in (73) for the Kikuya form [nēmbori]:

(73) 

Furthermore, Kikuyu exhibits a number of examples with vowels in hiatus, in which the hiatus is resolved by resyllabification, glide formation and subsequent compensatory lengthening. The following examples are taken from Clements and Ford (1980):

(74)	ke-agararɔ → kẹāgararɔ	'stile'
	mo-ana → mọāna	'child'
	mo-ere → mọēre	'body'
	mo-ɛnɛ → mọɛ̄nɛ	'owner'

If it is assumed that these forms result from complex segment formation (CSF), whereby the glide leaves its own timing slot and reassociates to the preceding consonant, with subsequent compensatory lengthening, the facts can be derived straightforwardly, as is shown in (75):

(75) 

In the remainder of this section, we will show that the postlexical rules of [ATR]-spreading and Compensatory Lengthening are sufficient to account for the bulk of Kikuyu vowel sandhis. One additional rule will be needed to account for the surface shape of the vowel /u/, if it appears as the right-hand vowel in a vowel sequence. However, this will not render our analysis more complex than others, since /u/ will require such a treatment in any analysis.

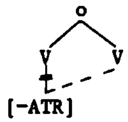
The analysis we will outline below draws heavily upon the theory of underspecification. In fact, in a theory of full specification, this analysis is impossible as will be made clear below. The seven-vowel system of Kikuyu will be represented as in (76):

(76)

	i	e	ɛ	a	ɔ	o	u
high	+						+
back	-	-	-				
round					+	+	+
ATR			-	-	-		

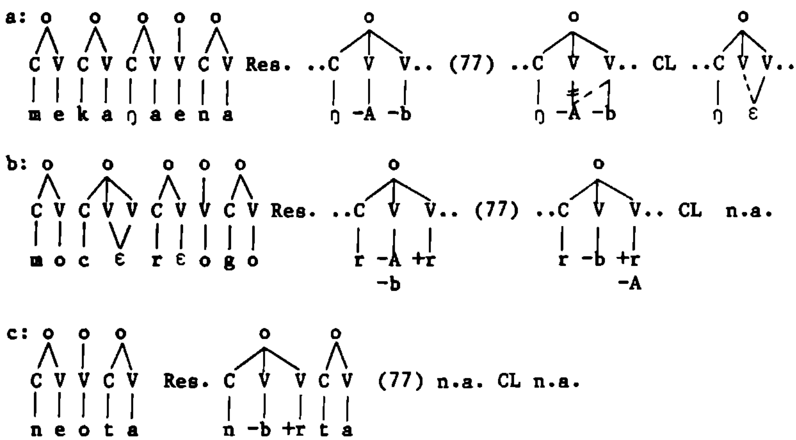
The first rule we want to propose is postlexical [ATR]-spreading. This rule differs in a number of ways from its lexical counterpart. We already pointed out that postlexically all [-ATR] vowels, including /a/, act as triggers and, furthermore, that the rule is confined to vowels in hiatus. We can express these differ-ences by assuming that [ATR]-spreading applies intrasyllabically. In addition to spreading, we can observe that [-ATR] must be delinked from its original position, unless spreading results in two identical vowels (cf. 70e). For the time being, we will ignore this latter set of data, and assume the following rule:[8]

(77) [ATR]-Spreading (postlexical)



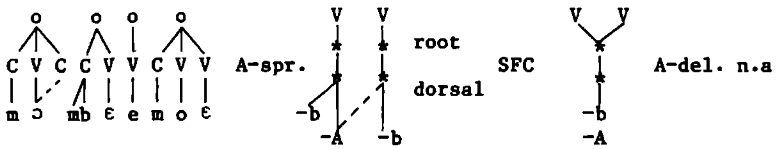
For the forms in (70a), that is, the a+V forms, [ATR]-spreading will result in an empty vowel slot, since the only feature specified on /a/ is [-ATR]. By ordering CL after [ATR]-spreading we can account for the differences between the a+V forms on the one hand and the ɛ+V and ɔ+V forms on the other in a straightforward manner, as is shown in (78):

(78)



The derivation in (78a) indicates that UT is crucial. If fully specified feature matrices were assumed, [ATR]-spreading would not yield an empty V-slot, and the independently motivated rule of CL could not apply. Hence, in such a model an additional rule of a+V coalescence would have to be assumed besides the processes of [ATR]-Spreading and CL. It is clear that the analysis outlined here is superior to analyses that do not take advantage of underspecification. Such analyses are simply more complex in that a larger number of rules must be assumed to account for a single set of facts.

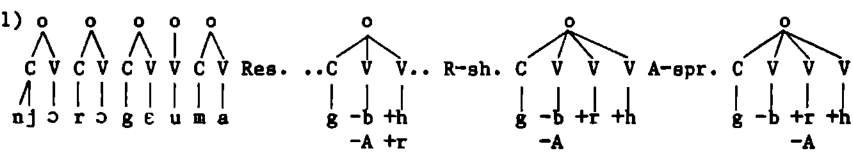
The forms in (70e) seem to present counterevidence for our analysis, since we apparently predict *ẹɛ and *ọɔ. This prediction would be false, since in forms like (70e) the long mid open vowels [ɛ̄, ɔ̄] occur. Hence, it appears that these forms undergo the assimilatory part of [ATR]-spreading, while the delinking part is blocked. We will propose that [ATR]-spreading actually consists of two separate subrules. If we furthermore invoke Clements' (1985) version of the Shared Features Convention, these forms are not problematical, since the spreading operation will result in two tautosyllabic vowels dominating the same set of features, and by means of the SFC all class nodes dominating shared feature complexes will merge. This implies that the structure yielded by the SFC cannot undergo the delinking operation, since it no longer fulfills its structural requirements. Hence, the SFC destroys the input for delinking. The interaction of [ATR]-spreading and the SFC is schematically illustrated in (79):

(79)


The final set of data to be considered is that of the V+u forms. For ease of exposition, we repeat the relevant examples in (80):

(80) a:	mbura-ura	→ mburɔịra	'rain, come down'
	mbɔgɔ-uma	→ mbɔgɔịma	'Mbogo, come out'
	njɔrɔgɛ-uma	→ njɔrɔgẹɔịma	'Njoroge, come out'
b:	ko-uneka	→ kūneka	'to break'
	nẹare-uma	→ nẹarẹuma	'he will come out'

These examples show that /u/ behaves differently after [-ATR] vowels than after [+ATR] vowels. In (80a) it undergoes a rule of [round]-shift which changes /u/ into [i] and at the same time accomplishes a rounding effect on the preceding vowel. The fact that ɛ+u forms result in a triphthong seems to indicate that the delinking of [round] involves an insertion of an additional V-slot to which [+round] associates. If we assume that the process of [round]-shift takes place before [ATR]-spreading and CL, we can neatly account for these facts. In (81), we illustrate the effects of [round]-shift for [njɔrɔgẹɔịma]:[9]

(81)


Before we conclude the discussion of vowel merger in Kikuyu, we want to raise the issue of the behavior of long vowels in hiatus. In general, sequences in which one of the input vowels is long remain heterosyllabic and the hiatus will be resolved by the insertion of a transitional glide, as observed by Sharp (1960):

(82) a:	ngū.o	'hippopotamus'
	θī.a	'diver'
	ndōkā.ɛgodɔ̄ma	'don't on any account read'
b:	amba.ōkɛ	'come first'
	mehēndɔ.ēre	'two ropes'
	njɔrɔgɛ.ūmanịōmba	'Njoroge, you have been in the hut'[10]
		(the dot indicates a syllable boundary)

The interest of the forms in (82) is that, for the first time, we encounter a difference in behavior between short and long vowels. In the languages discussed so far both short and long vowels undergo resyllabification and subsequent processes (e.g. Ancient Greek: dε̄lo-ete → dε̄lȏte and dε̄lo-ε̄te → dε̄lɔ̂te 'manifest'), and vowel length appeared irrelevant. The Kikuyu facts, however, show that differences in length can be crucially important in determining which of the available mechanisms must be selected. It is most likely that this difference between languages has to be decided on a language-particular basis.

Summarizing, the Kikuyu facts seemed problematic for the theory developed in this thesis because of the fact that only a subset of the nondistinct vowels in hiatus actually undergo merger. Hence, if a rule of vowel coalescence were involved, it would contradict at least one of the diagnostic criteria VC has to satisfy. In order to overcome this, we have suggested an alternative analysis of vowel hiatus in Kikuyu which lacks an independent rule of VC. All the facts can be accounted for by [ATR]-Spreading, [round]-shift and Compensatory Lengthening. The latter is independently motivated, as the data in (72) and (74) indicate. The lexical version of [ATR]-spreading can be observed in forms like (71). The data in (70) almost completely allow for an explanation by universal principles, such as the SFC in concert with a number of independently motivated language-specific rules.

5.5.3 Tunica

The native American language Tunica, formerly spoken near Marksville, Louisiana, is described by Haas (1940). The language exhibits two interdependent characteristics: (i) vowel sequences are not sustained, and (ii) syllables must be consonant-initial at the surface. Hence, it appears that Tunica is the prototype of a vowel coalescence language. However, a closer look at the facts reveals that the apparent process of VC violates a number of the diagnostic criteria. First, the result of hiatus resolution is a short vowel (e.g. míli áni → miléni 'it is red, they say'), while there is no independent proof for a vowel-shortening rule. Secondly, the input vowels are not necessarily tautosyllabic and the output vowels are not necessarily identical (e.g. mé ʔáki → méʔεki 'she searched'). Thus, three basic criteria are violated: (i) the quantity of the ouput vowel is not identical to the sum of the input vowels, (ii) the quality of the output is not a derivative of the quality of both input vowels, and (iii) assimilation is not confined to the domain of the syllable. Below, we will account for the Tunica facts without making reference to an independent rule of VC. We will essentially follow Hammond's (1984) analysis, who proposes two separate processes: Syncope and Backness/Rounding Harmony.

First, we will provide some background information regarding the phonology of Tunica. Haas (1940) states that syllables are basically of the type CV (sá 'dog'), CVC (tír.wa.ši 'claw, nail') and CVCC (hǎ.yiht 'on top of'). Furthermore, the vowel system consists of the vowels /i, e, ε, a, ɔ, o, u/. However, the distribution of the vowels is not fully random. The vowels /i, a, u/ occur freely, while the remaining vowels are more or less confined to stressed syllables. In addition, the vowels /ɛ, ɔ/ are not found in word-final position or preceding a nonlow vowel, and, conversely, the vowels /e, o/ do not appear before /a/. Hence, the following systematic gaps can be observed:

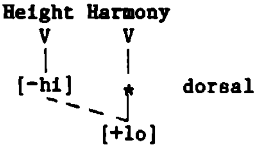
(83)	a: *ɛ #	b: *eCa	c: *ɛC /i, e, o, u/
	*ɔ #	*oCa	*ɔC /i, e, o, u/

According to Hammond (1984:167) these observations support a vowel-height harmony rule, which must, however, be restricted to monomorphemic words and particular suppletive polymorphemes, as is shown in (84):

(84)	a:	nɛ́ra	'ghost'	(*nera)
		lɔ́ta	'to run'	(*lota)
	b:	he-ra → hɛra	'you lie'	(*hera)
		he-hki → hehki	'you are'	(*hɛhki)
	c:	pó-kati	'she looks'	(*pɔkati)
		mé-kati	'she searched'	(*mɛkati)

Hammond assumes that the suppletive verbs in (84b) are stored in the lexicon, while the verbs in (84c) are not. On the assumption that Height Harmony (85) is a lexical rule, the differences in (84) follow:

(85) **Height Harmony**



When a vowel-final morpheme is prefixed to a morpheme that is vowel-initial or starts with a laryngeal consonant, a number of interesting alternations can be observed:

(86)	a:	ʔu-lu → ʔúlu	'his tongue'	
		ʔi-lu → ʔílu	'my tongue'	
		ʔu-ési → ʔósi	'his father'	
		ʔi-ési → ʔési	'my father'	
		ʔu-ančayi → ʔónčayi	'his wife'	
		ʔi-ančayi → ʔɛ́nčayi	'my wife'	
	b:	míli-áni → milɛ́ni	'it is red, they say'	
		tášle-áni → tašlɛ́ni	'it is beautiful, they say'	
		lúpitɛhɛ-áni → lùpitɛhɛ́ni	'she did not die, they say'	
		mólʔɔhɔ-áni → mòlʔɔhɔ́ni	'it is not full, they say'	
		mólu-áni → mólɔni	'it is full, they say'	
		nára-áni → nárani	'it is a snake, they say'	
	c:	míli-ʔáha → mílʔɛhɛ	'not red'	
		mólu-ʔáha → mólʔɔhɔ	'not full'	
	d:	ʔúwi-hat → ʔúwɛt	'on his part'[11]	
		tánaraku-hat → tánarakɔt	'the snake, on his part'	
		ʔúnima-hat → ʔúnimat	'we, on our part'	

Although it looks as if two vowels (in hiatus) merge into a single vowel with the backness and rounding values of the first input vowel and the height of the second input vowel, Hammond (1984) shows that two independent processes are at work: a rule of vowel harmony and a rule of syncope. Evidence for this is given in (87) below. The forms in (87a) show the effect of vowel harmony without subsequent syncope and the forms in (87b) show syncope without vowel harmony. The forms in (87c) furthermore show that the rule of vowel harmony applies to any vowel in an unbounded fashion until an opaque segment blocks its propagation:

(87)	a:	mé-ʔaki	→ méʔɛki	'she searched'
		pó-ʔaki	→ póʔɔki	'she looked'
	b:	káku-ʔihpóʔuhki	→ kàkʔihpóʔuhki	'someone has seen me'
		títihki tʔɛ́	→ tìtihktʔɛ́	'river'
	c:	lúpi-ti-ʔáha-áni	→ lùpitɛhɛ́ni	'she did not die, they say'
		mólu-ʔáha-áni	→ mòlʔɔhɔ́ni	'it is not full, they say'
		ʔu-éhekuma-ku	→ ʔóhokumaku	'his younger brother'

The crucial difference between (87a) and the other forms in (86) and (87) seems to be determined by stress. The left-hand vowel does not show up at the surface if it is unstressed. Hammond (1984:171) therefore formulates a syncope rule deleting an unstressed vowel when it precedes a vowel with a possible intervening laryngeal consonant /ʔ/ or /h/:

(88) Syncope

$$V \longrightarrow \emptyset \; / \; \text{—} \; ([+\text{glot}]) \; V$$

This syncope rule must be ordered after the rule of vowel harmony which spreads the values for [round] and [back] to the right, until it reaches an opaque segment. Hammond (1984:170) presents a preliminary formulation of this Backness/Rounding Harmony rule, which expresses the fact that a nonhigh vowel agrees in backness and rounding with the preceding vowel, possibly across an intervening laryngeal consonant:

(89) Backness/Rounding Harmony

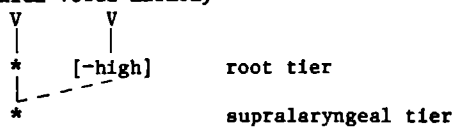
$$\begin{array}{c} V \\ | \\ [-\text{hi}] \end{array} \longrightarrow \begin{bmatrix} \alpha\,\text{bck} \\ \beta\,\text{rnd} \end{bmatrix} \; / \; \begin{array}{c} V \\ | \\ \begin{bmatrix} \alpha\,\text{bck} \\ \beta\,\text{rnd} \end{bmatrix} \end{array} \; ([+\text{glot}]) \; \text{—}$$

Within the framework of nonlinear phonology proposed here, this formulation cannot be maintained, since it involves the spreading of two independent articulator nodes, viz. Labial and Dorsal, a kind of spreading prohibited or at least highly marked. Furthermore, if the rule expresses the spreading of the single features [round] and [back], we predict that any consonant should be transparent, whereas the data show that only the laryngeals /h, ʔ/ are.

Steriade (1987a) argues that processes assimilating vocoids to vocoids across laryngeals are fairly widespread. She also observes that these processes share a catalogue of properties: (i) only the laryngeal consonants /h, ʔ/ count as transparent, (ii) translaryngeal harmony is always multiple-feature harmony; i.e. it cannot be characterized as the spreading of a single articulator node, (iii) it does not differentiate between the laryngeals /h/ and /ʔ/, and (iv) it never requires /h, ʔ/ to intervene: it merely allows them to do so.

All these properties follow rather naturally, according to Steriade, if it is assumed that translaryngeal harmony involves the spreading of the supralaryngeal or place node. In that case it is predicted that the laryngeal features of the participating vowels will remain unchanged, and one expects the full complex of place features of the vocoids to propagate. Finally, one expects the laryngeals to be transparent, since they rather than the true consonants lack a supralaryngeal node. The rule of Backness/Rounding Harmony can now be reformulated as in (90) below. Following Steriade (1987a), we arbitrarily assume that spreading takes place at the level of the supralaryngeal node:

(90) Tunica Vowel Harmony



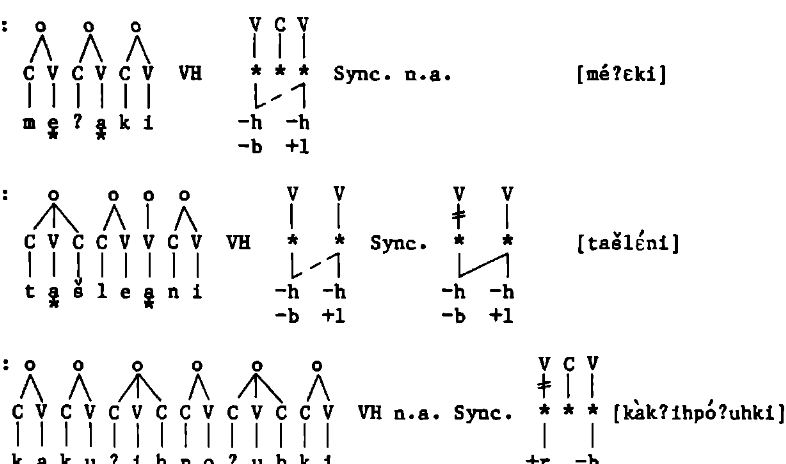
For this analysis to work properly, we must assume that the vowel system of Tunica is that of (91):

(91)

	i	e	ɛ	a	ɔ	o	u
high		-	-	-	-	-	
low			+	+	+		
back	-	-	-				
round					+	+	+

The consequences of this analysis are illustrated in (92) for a number of relevant examples:

(92)



(V̥ indicates a stressed vowel)

From these derivations we can draw the conclusion that no rule of VC is active in Tunica phonology. All the data discussed can be described, if we assume the translaryngeal rule of Vowel Harmony (90). Hence, the resolution of vocalic hiatus in Tunica is the ultimate result of the interaction of VH (90) and Syncope (88). This language therefore does not present any problem for our theory. As a matter of fact, it turns out that the criteria which we have established to identify vowel coalescence are precise enough to discriminate between true VC languages and apparent VC languages. Since the way in which vocalic hiatus is resolved in Tunica violates three out of the five diagnostics established, we expect that no rule of VC is involved. We can infer from the analysis presented that this expectation is correct.

5.5.4 Washo

Washo is a Hokan language, spoken in Northern California and Nevada. The major sources for this language are Jacobsen (1964) and Winter (1970). Recently, Broselow and McCarthy (1983), and McCarthy and Prince (1986) have attempted to analyze its recalcitrant reduplication system, using the framework of nonlinear phonology. This phenomenon is intriguing to us, because it seems to involve a process of vowel coalescence between the final vowel of the infix and the first vowel of the stem. Broselow and McCarthy (1983), following Winter (1970), identify the infix as VCV, which is inserted after the initial consonant and before the first vowel of the stem. A handful of examples is given below:

(93)	singular	plural	
a:	dáʔa	daʔáʔa	'mother's brother'
	ʔélel	ʔelélel	'mother's father'
	bókoŋ	bokókoŋ	'to snore'
	bínil	binínil	'to try'
b:	mó̄k'o	mok'ó̄k'o	'knee'
	k'ī́li	k'ilī́li(yi)	'it is raining'
	hḗne	henḗne(yi)	'it is roaring'

Hence, if the reduplicative affix takes the shape VCV, the plurals of bókoŋ and mṓk'o will be /b-oko-ókoŋ/ and /m-ok'o-ṓk'o/, respectively. According to Broselow and McCarthy, a rule of vowel coalescence will change the o+ó and o+ṓ sequences into a single [o], which vowel will retain the original stress and distinct quantity of the second input vowel.

Of course, examples like those in (93) do not show that the reduplicative infix should be VCV. However, when we look at stems with non-identical vowels, it becomes clear that vowel coalescence merges two vowels into a vowel whose properties are a combination of the properties of the input vowels. These data are presented in (94):

(94)	singular	plural	
a:	t'ánu	t'anóno	'person'
	ʔā́t'u	ʔat'ṓt'o	'older brother'
b:	báliʔ	baláliʔ	'to shoot'

```
c: p'ísew          p'isésew        'ear'
   šémug           šemúmug         'brother's child (of a woman)'
d: c'íge           c'igége         'to scratch'
   sísu            sisúsu          'bird'
```

Broselow and McCarthy claim that the underlying representation of the forms are /p'+ise+ísew/..etc. and they posit a vowel coalescence rule with the following properties:

(i) A round vowel followed by /a/ yields /o/. Subsequently, a rule of vowel harmony propagates /o/ rightward, affecting a following /u/, e.g. /t'+anu+ánu/ → [t'anóno].

(ii) Any other vowel followed by /a/ yields /a/, e.g. /b+ali+áli?/ → [baláli?].

(iii) Any vowel followed by a vowel other than /a/ yields a vowel identical to the first vowel, e.g. /š+emu+émug/ → [šemúmug].

It will be clear that this type of VC differs in a number of ways from the genuine type. First, as is already observed by McCarthy and Prince (1986:52) "the reduplicative affix VCV is obviously not straightforwardly discoverable from the alternations...[since] the difference between the singular and plural is simply that the latter is larger by one monomoraic syllable..." In other words, the reduplicated form contains a CV syllable which does not appear in the singular. Second, the length of the output vowel is not identical to the sum of the input vowels. Furthermore, it seems that the length of the second input vowel is preserved throughout and this is a peculiar property that we have not encountered before.[12] Finally, VC in Washo would violate the criterion that the quality of the output vowel is a derivative of the quality of both input vowels and that all prespecified feature values are preserved. The observation that sometimes the first vowel, sometimes the second, and sometimes a mixture of both appears on the surface is a blatant contradiction of this general characteristic of VC. Below, we will tackle the problem of infixing reduplication from a different perspective. The analysis to be put forward is inspired by that presented in McCarthy and Prince (1986), although it differs from their analysis in a number of ways.

Our analysis differs from all previous ones to the extent that we assume that the segments making up the initial syllable of the stem are extrametrical, and therefore invisible to the copying rule. Finally, we will assume that the copied material will associate from left to right in a one-to-many fashion to the available slots. In all other respects, our analysis conforms to the theory of reduplication outlined in Marantz (1981), and subsequent work. We will illustrate the consequences of this analysis for some simple forms:

```
(95) a: C V C V  inf.  C V + C V + C V  Copy  C V + C V + C V
        | | | |        | |         | |   +    | |   : :   | |
        d a ? a        (d a)       ? a  Ass.  d a   ? a   ? a

     b: C V C V C inf. C V + C V + C V C  Copy  C V + C V + C V C
        | | | | |      | |         | | |   +    | |   / /   | | |
        p'i s e w      (p'i)       s e w  Ass.  p'i   s e w s e w
```

These derivations show that we do not have to assume a rule of VC to account for the forms in (93a) and (93c).[13] The forms in (93b) and (94d) are slightly more complicated, since in these forms the infix must be inserted inside a long vowel. Given the prohibition on the crossing of association lines, we must assume that the stem vowel delinks from its rightmost slot to allow the association of the copied material. This aspect of the analysis is shown in (96):

```
(96) C V V C V  inf.  C V + C V + V C V  Copy  C V + C V + V C V
     | \/  | |        | |__________/ | |    +   | |   : :.-'   | |
     m  o  k'o       (m o)           k'o  Ass.  m o   k'o      k'o
```

Once again, it turns out that no rule of VC needs to be assumed for the forms where the first stem vowel is long. The examples that seem to provide the strongest evidence for a rule of VC are those in (94a), where a+u seem to merge into a single /o/. However, in addition to this change these forms are peculiar in another respect: it is not only the first stem vowel that is affected, but also the second vowel /u/ is lowered to /o/. The mechanisms introduced so far will result in *t'anunu and *ʔat'ūt'u...etc. If we assume a process of vowel harmony which propagates [-high] from the vowel /a/ to any following round vowel, the forms in (94a) are no longer problematic. We would like to emphasize that the assumption of a rule of vowel harmony does not render our analysis more complex than the previous ones, since in these analyses an almost similar kind of rule must be assumed to cover the change of the final stem vowel /u/ to /o/:

```
(97) C V C V       C V + C V + C V Copy C V C V C V      C V C V C V
     | | | | inf | |             | |  +   | | : : | |  VH  | | | | | |
     t'a n u    (t'a)            n u Ass. t'a n u n u      t'a n o n o
```

Still problematic for our analysis, though, are forms like (94b), for which we wrongly derive *baliliʔ instead of baláliʔ 'to shoot'. We will return to these data shortly, since they belong to a larger set where the first stem vowel unexpectedly shows up in the infix. We will first discuss the vowel-initial stems, as these forms provide additional evidence for the claim that the infix is inserted immediately after the first V slot of the stem:

(98)	singular	plural	
a:	íc'iš	c'íc'iš	'black'
	íleg	léleg	'red'
	ī́hu	hū́hu	'striped'
	íšɨš	šɨ́šɨš	'heavy'
	ásuŋ	sósoŋ	'red'
b:	ác'im	c'ác'im	'green, yellow'
	ā́t'i	t'ā́t'i	'upwards, uphill'
	áp'ɨl	p'áp'ɨl	'tail'
	ā́p'ɨg	p'ā́p'ɨg	'to cut, sever'

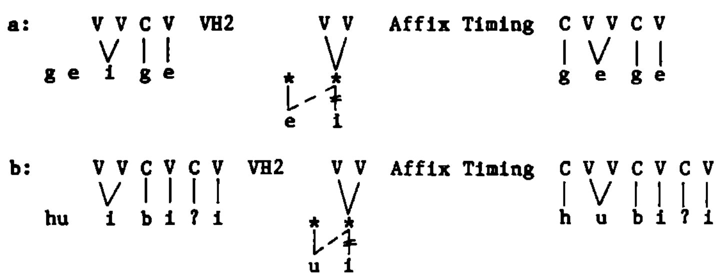
By reduplication we derive forms like /i+c'i+c'is/. However, it appears that in all these cases the word-initial vowel is absent. Winter (1970) states that the absence of unstressed word-initial vowels is by no means accidental, since there are no phonological words in Washo that begin with an unstressed vowel. Broselow and McCarthy (1983:49) propose the following vowel deletion rule,

(99) $V \rightarrow \emptyset \;\; / \;\; \# \, [-\overline{\text{stress}}]$

which deletes any unstressed vowel in word-initial position. The forms in (98a) present no further difficulties, but this is clearly not the case for the forms in (98b). Hence, we derive /a+c'i+c'im/ by reduplication and *c'ic'im by vowel deletion. Notice, though, that these forms are problematic in essentially the same way as (94b): in both cases we predict a high vowel /i/ or /ɨ/, instead of the low vowel /a/. In addition to these problematic forms there are others showing the same typical behavior. Examples are given in (100):

(100) a: dɨ́ni (sg.) dɨnɨ́ni (pl.) 'it is roaring' (*dɨnīni)
b: ge-Īge → gége 'grind'(imp.) (cf. ge-béyu 'pay him' (imp.)
c: be-Ībi? → bébi? 'to have come'
d: hu-Ībi?-i → húbi?i 'came'

All these forms show that the high vowels /i, ɨ/, when preceded by a vowel, fail to show up, in recognition of which we can propose a second rule of vowel harmony which spreads the vocalic features to a following high vowel with concomitant delinking of the high vowel. The effects of this operation are illustrated in (101):[14]

(101)


Finally, we want to touch on two further issues that do not directly relate to the question whether Washo is a true VC language, in order to provide additional evidence for our analysis, we will discuss stems with medial consonant clusters, and second we will consider another example of deassociation of long vowels from their rightmost slot. Our purpose is to show that this type of deassociation is not unprecedented. The data in (102) reveal that in the case of stems with medial consonant clusters, it is the second consonant that appears in the reduplicated form:

```
(102)    singular          plural
      a: ípc'ib            c'ípc'ib       'perfect'
         álbul             bólbol         'spherical'
         élšɨm             šélšɨm         'to sleep'
      b: ?éwši?            ?ešiwši?       'father's brother'
         nént'uš           net'únt'uš     'to be an old woman'
         mókgo             mogókgo        'shoe'
```

These forms require some special treatment in the analyses of Broselow and McCarthy (1983) and McCarthy and Prince (1986). In the former it is assumed that association proceeds from right to left in these cases while under normal circumstances association proceeds in the opposite, unmarked direction. McCarthy and Prince attribute the choice of the second consonant to a special property of their Onset Rule. In the analysis presented here, these forms are not very special. Recall that we have assumed that the segments making up the initial syllable of the stem are extrametrical which renders them invisible to the copy rule. As a consequence, the first consonant in the medial cluster cannot be copied and by association we derive the correct surface forms:

```
(103) a: V C C V C        V + C V + C C V C Copy  V + C V + C C V C
         | | | | | inf.   |         | | | |  +    |    / /   | | | |
         i p c'i b       (i         p)c'i b Ass.  i   c'i b  p c'i b

      b: C V C C V C        C V + C V + C C V C Copy C V + C V + C C V C
         | | | | | | inf.   | |         | | | |  +   | |    / /   | | | |
         n e n t'u š       (n e         n)t'u š Ass. n e   t'ú š  n t'u š
```

Concerning the delinking of long vowels, Lehiste (1985) discusses an Estonian word game that involves the insertion of the syllable pi after the first vowel of the base. It turns out that this word game exhibits the same properties as CV-infixation in Washo. Some of the clearest examples are given in (104):

```
(104) a: laulus [laúlus]  [lapiúlus] 'in the song' (long diphthong)
         seadus [seádus]  [sepiátus] 'law'(nom.sg.) (overlong diphthong)
      b: sada   [sáta]    [sapíta]   'hundred' (short vowel)
         saada  [sā́ta]    [sapī́ta]   'send'(2sg.imp.) (long vowel)
         tuum   [tū́m]     [tupī́m]    'kernel'(nom.sg.) (overlong)
         liim   [lī́m]     [lipī́m]    'glue'(nom.sg.) (overlong)
```

These forms show that Estonian has a three-way distinction of vowel length. In the remainder, we will not indicate this difference between long and overlong vowels, since it is irrelevant to the point made. The forms in (104a) can be derived straightforwardly within CV Phonology, as shown below:

```
(105) C V V C V C  →  C V + C V + V C V C
      | | | | | |     | |   | |   | | | |
      l a u l u s     l a   p i   u l u s
```

In (104b), on the other hand, pi is inserted inside an (over)long vowel. We observe that the melody of the first vowel in the base shows up to the left of the infix, is destressed and phonetically short. The inserted infix vowel appears in a lengthened form, though,and this implies that basically the same mechanisms are at work as in Washo infixation:

```
(106) C V V C V →  C V + C V + V C V →  C V C V V C V
      | \/  | |    |  |    |       | |   | | | |   | |
      s  a  t a    s a     p i     t a   s a p i   t a
```

We summarize as follows: at first sight, Washo seems to be a VC language, which, if so, would violate two of our diagnostics. It turned out that an alternative analysis of the facts is possible lacking a rule of VC. In this analysis, we simply have to assume two rules of vowel harmony: one which lowers /u/ to [o] if the low vowel /a/ preceeds, and a second which changes the high vowels /i, ɨ/ into the quality of the vowel of the preceding syllable. In comparison to the previous analyses ours is by no means more complex, since the rules responsible for these changes must be posited anyway. The fact that no independent rule of VC is required, that for both consonant and vowel-initial stems infixation takes place after the first stem vowel, and, finally, that no special assumptions are needed for stems with medial consonant clusters, renders our analysis superior to all previous ones.

5.5.5 Conclusions

Several apparent VC languages have been reviewed in this section. All of them violate at least one of the basic properties of vowel coalescence. We have shown that in each case an alternative analysis is possible and even preferable. For Kasem, the theory of underspecification enabled us to posit a single rule of Vowel Lowering in addition to the general rule of Vowel Truncation. In Kikuyu the independently motivated processes of [ATR]-spreading and Compensatory Lengthening were shown to be responsible for the apparent a+V mergers. For Tunica, we followed the analysis presented in Hammond (1984), who convincingly showed that the vowel mergers in this language are the result of a rule of vowel harmony and a stress-dependent rule of Syncope. Finally, we paid attention to infixing reduplication in Washo. This language seemed to present evidence for a process of vowel coalescence between the final vowel of the infix and the first vowel of the stem. However, we showed that the infixation facts were misanalyzed in previous accounts. First, the infix is not VCV but CV, and secondly, the infix is not inserted after the initial C-slot, but after the first V-slot of the stem. In addition to these assumptions two rules of vowel harmony are required to account for this intricate process of infixing reduplication.

5.6 Summary

In this chapter we explored vowel sandhi phenomena in a variety of languages. It turned out that only a small subset of these languages show a rule of VC that satisfies the basic criteria established in chapter 2. For the apparent VC languages it was relatively easy to show that an independent rule of VC was superfluous, since the data could be handled by straightforward vowel-to-vowel assimilation rules.

The true VC languages were not selected randomly. Instead, the choice was largely determined by a desire to gather additional evidence for a general theory of vowel coalescence that could not be constructed on the basis of Ancient Greek alone. Quebec French was included because the language provides crucial confirmation for the claim that merger involves the supralaryngeal node in the feature geometry. At the stage of the derivation where VC takes place, this language distinguishes oral and nasal vowels, and if at least one of the input vowels is a nasal vowel, the output is nasal too. The simplest way of expressing this observation is by assuming that merger takes place between supralaryngeal nodes, since this is the first class node that dominates both the nasal and place features. Korean and Rotuman support the claim that VC is a process which preserves all prespecified feature values. The ensuing prediction is that nonunderlying phonemes may arise in the course of the derivation. The properties of VC in both languages reveal that this is what actually happens. Finally, Old Portuguese and Classical Sanskrit were selected, because in these languages high vowels in hiatus are observed to behave differently. In Old Portuguese, merger of vowels distinct in height is ruled out. The absence of merger is due to an earlier rule of Vowel Raising which changes unstressed mid vowels into high vowels. Consequently, the high and nonhigh vowels are distinct and thus cannot undergo VC without refuting the claim that VC is non-feature changing. In Classical Sanskrit, high vowels participate in VC, causing the merger of V+i and V+u into a long monophthong. Only if high vowels occur in prevocalic position or after long vowels, VC does not apply. The reason for this is that the high vowels are syllabified outside the syllable nucleus, while VC is confined to this domain, at least in Sanskrit.

Finally, we have discussed a number of apparent VC languages, which did not meet the diagnostic criteria we established to distinguish a true VC language. We presented analyses of these languages in which we showed that separate rules of VC are superfluous. Positing rules of VC would lead to unwanted duplications and missed generalizations in the grammar of each individual language.

Footnotes

1: The rule of Consonant-Labialization as formalized in (8) spreads two feature nodes simultaneously: [+round], dominated by the labial node, and [-back], dominated by the dorsal node. Given the hypothesis that assimilation rules can affect only a single node in the feature geometry, Consonant-Labialization presents a problem for this hypothesis. We will not go into this issue here, but it seems reasonable to assume that (8) is a telescoping of two separate rules of palatalization and labialization, the more so since Quebec French has an independent rule of palatalization.

2: Forms exhibiting the sequence /u-ə/ show a three-way alternation.

For example tu-ə [tu.ə] ~ [tō] ~ [twə] 'to leave'. The latter form is the result of glide formation, a rule which we will not discuss.

3: Following Kiparsky (1979), among others, we will assume that low vowels are more sonorous than mid vowels, and mid vowels more sonorous than high vowels. Consequently (ă, a, ɔ) > (e, o) > (i, u).

4: There is some disagreement about the feature specification of the mid vowels phonetically represented as [ẹ] and [ọ]. Naro (1971) characterizes them as [-high, +low], while Williams (1962) and more recently Redenbarger (1981) identify these vowels as phonetically equivalent with the English 'lax mid vowels', that is, [-high, -low, -ATR]. We will adopt the latter view, although nothing is crucial about this choice. The same results can be obtained if /ɛ, a, ɔ/ are specified as [+low] instead of [-ATR].

5: The rule of VR seems to include the unstressed vowels /ɛ, a, ɔ/, although these vowels do not undergo VR. We can nevertheless maintain the statement in (39) for two reasons. First, the vowels /ɛ, ɔ/ do not appear outside stressed syllables, and therefore these vowels will never meet the structural description of the rule. Second, recall that we have broadened the scope of the Linking Constraint to all structure-dependent processes (cf. section 1.3). The representation of the half-closed vowels /e, o/ versus the half-open and open vowels /ɛ, a, ɔ/ in (i) reveals that the latter set of vowels are immune to VR, since their structure does not satisfy the structural description of the rule:

(i) Dorsal:

```
   *                 *
   |                / \
 [-hi]        [-hi]  [-ATR]
```

6: Harry van der Hulst (personal communication) has correctly pointed out that a special rule of vowel coalescence is superfluous if single-valued features are assumed. The analysis we present shows that the same advantage can be obtained from the model of underspecification advanced here.

7: Wetzels (1988) discusses a similar situation in Brazilian Portuguese. He observes that the feature [ATR] is only distinctive in the mid vowel series, while it is predictable in the high and low series. He therefore proposes to leave /a/ and /i, u/ unspecified for [ATR]. At a later stage in the derivation he fills in [-ATR] by an R-rule, and all subsequent processes take /a/ on a par with the distinctively marked [-ATR] vowels. It is unclear to us how Wetzels' analysis of Brazilian Portuguese can be applied to Kikuyu, and we therefore leave this issue for future research.

8: The vowels /i, u/ are not affected by [ATR]-spreading. We can account for this fact in two different ways. First, we can assume that the rule itself is restricted to nonhigh vowels, which we can express by changing postvocalic high vowels into glides. Alternatively, we can assume a filter which rules out the [-ATR, +high] vowels /ɩ, ʊ/ both lexically and postlexically. We have no arguments in favor of either of these approaches.

9: The diphthongs $\bar{a}$i̯, $\bar{\varepsilon}$i̯, $\bar{ɔ}$i̯...etc. do not occur. We assume a postlexical rule shortening these diphthongs when they arise in the course of the derivation.

10: There is a set of systematic exceptions, to which belong the demonstratives ērẹa 'those' and ɔ̄rẹa 'that', where the hiatus is always resolved by resyllabification (e.g. megɔ̄ndɛ̄rẹa 'those farms (over there)', mocɛ̄reɔ̄rẹa 'that rice'). We will not try to incorporate these marginal facts into our analysis.

11: The sequence 'consonant plus /h/' never occurs in Tunica at the surface. When it arises by means of a word-formation rule or by syncope, /h/ is deleted (e.g. ʔin+htatʔ → ʔintatʔ 'our brother', ʔuwi+hat → ʔuwihɛt → ʔuwhɛt → ʔuwɛt 'on his part').

12: McCarthy and Prince (1986:52) make a similar observation. They state that this type of length preservation is abnormal cross-linguistically and that VC typically yields vowels that are long or short uniformly in any language.

13: The stress pattern of the plurals does not constitute a problem, if it is assumed that stress assignment takes place after reduplication. The stress rule of Washo seems to be rather trivial, representing a bounded, left-dominant, quantity-insensitive system, as a consequence of which the penultimate syllable will receive main stress.

14: McCarthy and Prince (1986) convincingly show that morphemes such as ge-, hu-..etc. are represented lexically without prosodic structure, i.e. as untimed morphemes. We already encountered examples of untimed morphemes in Kasem, where the singular suffixes are proposed to be untimed.

In SPE Chomsky and Halle took the position that phonological representations of utterances consist of strings of linearly ordered matrices which contain unordered sets of binary distinctive features. They themselves were the first to emphasize that their model was unlikely to be the most suitable candidate for suprasegmental phenomena such as tone. The appearance of Leben (1973), Williams (1976), and especially Goldsmith (1976), led to a thorough rethinking of the form and content of phonological representations and phonological rules. Intensive study of prosodic phenomena gave rise to a three-dimensional model of representation, comprising a string of CV or timing positions, onto which the independent syllable and melody planes are projected. Since then, a steady flow of publications appeared in which it was shown that, on both theoretical and empirical grounds, the monolithic view of the representation of sounds of SPE could not be maintained.

One of the segmental processes that linear phonology cannot very well cope with is vowel coalescence. The basic characteristic of this phenomenon is that the input vowels contribute jointly to the quality and quantity of the output vowel, which means that the input vowels are trigger and target at the same time. The output vowel can therefore be conceived as a derivative, or an articulatory compromise of the input vowels. In SPE, Chomsky and Halle took the existence of rules of vowel coalescence and metathesis as sufficient motivation for the introduction of rules with transformational power. However, the excessive descriptive capacity of transformational rules makes it nearly impossible to discriminate between possible and impossible rules of vowel coalescence.

The aim of this thesis was to develop a formal nonlinear theory which would enable us to discriminate between possible and impossible (or highly marked) types of Vowel Coalescence.

The foundation for this formal theory was laid out in chapter 1, which focused on two recently developed theories, viz. Clements' (1985) and Sagey's (1986b) theories of hierarchical feature representation, and Kiparsky's (1982, 1985) and Archangeli's (1984) theories of underspecification. For both of these, we proposed a number of refinements. Furthermore, we paid attention to two important constraints on the application of phonological rules, viz. the Linking Constraint and the Strict Cycle Condition.

Clements (1985) and Sagey (1986b) assume that segments are hierarchically structured in underlying representation. Under this view, distinctive features are terminal nodes organized under hierarchical superordinate nodes, such as 'place-of-articulation', 'supralaryngeal', 'laryngeal' and so forth. These class nodes themselves are dominated by a yet higher-level node called the root node, which is immediately linked to the skeleton. Hence, a segment is composed of two types of melodic tiers: (i) the non-terminal class tiers, and (ii) the terminal feature tiers. We alternatively proposed to derive the feature geometry in the course of the derivation by means of the device of tier decomposition, a proposal which boils down to the following: in underlying representation only a small number of tiers is posited including a CV tier and a unitary, unstructured melodic tier. New tiers are created by the universal mechanism of tier decomposition which makes phonological features or classes of features available to autosegmental operations of spreading, deassociation and association. We brought forward a number of theoretical and empirical arguments supporting these ideas, which, taken together, suggest that the static view of feature representation is too powerful, and allows for phonological processes that do not occur in human languages. For example, rules of transposition (metathesis, speech errors, word games) are of a particularly restricted type, since transpositions of single features or classes of features are systematically excluded. In theories in which the segment (root node), classes of features (class nodes) and single features are available underlyingly, we cannot rule out these impossible types of transposition. In the theory advanced here, the only stipulation is that rules of transposition are restricted to underlying representation, since at this level subclasses of features are still inaccessible. Furthermore, the mode of tier decomposition enables us to draw a formal distinction between rules that are deeply embedded in the lexicon and autosegmental spreading rules. A P-rule of the former type does not trigger tier decomposition, but simply fills in or changes features without affecting the integrity of a segment. P-rules of the second type cause tier decomposition and destroy the integrity of individual segments. At least for the English rule of Velar Softening, it appeared that we do not have to mark this rule as an early lexical rule, since its status can be inferred from the fact that the features mentioned in the structural description do not match the structural description of any tier decomposition rule (cf. chapter 1). Consequently, the only means to bring about the desired changes is to apply Velar Softening in a linear fashion. One prediction made by the claim that Velar Softening is a pre-decomposition rule is that we expect that the output of the rule is not sensitive to the Linking Constraint. This prediction is borne out, since Vowel Shift can apply freely to long vowels that have previously triggered Velar Softening.

The second theory crucially invoked is underspecification theory. Kiparsky (1982, 1985) and Archangeli (1984) propose a theory of minimal specification. This theory embodies the claim that of a particular feature only the values [aF] and [0F] are present underlyingly (where "a" is "+" or "-"). With regard to the processes discussed in this thesis, this concept seems to be appropriate, and in many cases even preferable to a system with fully-specified representations. However, we have raised a number of problems which were serious enough to challenge the overall adequacy of the minimal specification model. Especially with respect to the major class features and in the case of elaborate consonant systems, it is doubtful whether the descriptive power of this type of radical underspecification is ever employed in human languages.

For the major class features there is no evidence whatsoever that one value remains unspecified. Furthermore, Steriade (1987b) discusses several processes for which it is crucial that both [+F] and [-F] are present in the class of segments in which [F] is distinctive, while the value for [F] is unspecified in the class in which [F] is redundant. For example, the proper description of Latin lateral dissimilation requires that both liquids /l, r/ are specified for [lateral], while the remaining segments are unspecified for this feature. Otherwise, lateral dissimilation could not be stated as a local rule affecting adjacent nodes on a single tier.

To get the advantage of both minimal and nonminimal specification, we have proposed an underspecification theory that is close to the approach of the Prague School, and that of Steriade (1987b). Concretely, we have assumed that both values of a feature [F] are fully specified in the class of segments in which [F] is distinctive, while the value for [F] is unspecified in the class of sounds in which it is redundant. The full power of minimal specification is put to use only if language-internal evidence makes this desirable. When certain segments, features, or feature combinations show asymmetrical properties in a certain language by failing to participate in phonological processes, we took this as evidence for the fact that they are unspecified underlyingly. For example, the vowel /e/ behaves differently from the other vowels in Spanish in many respects (cf. Harris 1980) and Ancient Greek (cf. chapter 3); the feature [-round] never instantiates a vowel harmony system, while rounding harmony systems are widespread; and finally, the Mid tone in Yoruba (Pulleyblank 1983, Akinlabi 1984) does not induce tone spreading, and is not preserved under vowel deletion, contrary to both the High and Low tone.

We concluded the exposition in chapter 1 by discussing two important constraints on rule application: the Linking Constraint and the Strict Cycle Condition, and its function in Lexical Phonology.

The Linking Constraint states that association lines between autosegments on two tiers mentioned in the structural description of a P-rule must be interpreted as the sole associations connecting either autosegment to elements on the other tier. The discussion in Hayes (1986a), Schein and Steriade (1986) and Itô (1986) focuses on structure-dependent rules referring simultaneously to the CV skeleton and the melody tier. We have argued to extend the scope of the Linking Constraint to all structure-dependent rules including rules that refer to two melody-internal tiers. The major advantage of this position relates to redundancy. Given the Linking Constraint, we do not need to include redundant feature values into the structural description of a number of phonological rules. For example, in Ancient Greek, the nonhigh vowels /ɛ̄, ā/ undergo partial resyllabification or retiming by means of Metathesis of Quantity, while the nonhigh vowel /ɔ̄/ does not. In previous accounts of this phenomenon, the features [-round] or [-back] had to be referred to, but the problem is that these feature values are redundant and therefore unspecified in Greek. By assuming the Linking Constraint, it is unnecessary to mention these redundant values in the statement of the rule, since we can distinguish between /ɛ̃, ã/ on the one hand and /ɔ̃/ on the other in purely structural terms. In the former set of vowels, the place node is associated to the dorsal node, while in the latter the place node dominates the dorsal as well as the labial node.

The Strict Cycle Condition is a condition on one particular set of P-rules, viz. the cyclic rules applying in the lexical component of the grammar. Its major effect is to confine cyclic rules to derived environments. It accounts, for example, for the difference between nightingale and divine+ity with respect to Trisyllabic Shortening. This rule shortens the antepenultimate vowel in divinity, but leaves the long vowel in nightingale unaffected. We have suggested, following Kiparsky (1982) and Hermans (1986, forthcoming), that the Strict Cycle Condition is not a primitive of linguistic theory. The effects of this principle are derivable from other independently motivated principles. Kiparsky proposes to deduce its effects from the introduction of identity rules and the Elsewhere Condition. Hermans on the other hand, derives its effect from Chomsky's (1981) Projection Principle. These proposals both allow cyclic rules to apply to underived lexical forms, if they are structure building and nonneutralizing.

With these theories as points of departure, we developed a formal theory of vowel coalescence in chapter 2. We argued that a process can only lay claim to this name if it satisfies the following diagnostics:

(i) the quality of the output is a derivative or articulatory compromise of the quality of the input vowels.

(ii) the quantity of the output is the sum of that of the input vowels, that is, the skeleton and all higher level prosodic unit are unaffected by VC.

(iii) all lexically specified feature values are preserved, irrespective of whether the output vowel is underlyingly present.

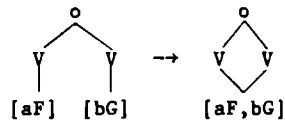
(iv) merger of segments is confined to the domain of the syllable or syllable nucleus.

(v) the trigger and target vowel are indistinguishable, and VC is therefore inherently bidirectional.

We showed that the framework of linear phonology is incapable of accounting for these characteristics in a principled way. Most importantly, by assuming the normal rule format of linear phonology, both the quality and quantity of the output are derived by accident.

To account for the basic criteria, we claimed that VC is triggered by resyllabification, which ensures that the possible input vowels are tautosyllabic. We explained the remaining characteristics by claiming that VC accomplishes a purely melody-internal change which leaves the CV skeleton unaffected, and furthermore involves the merger of nondistinct supralaryngeal nodes in the feature geometry. In outline, VC takes the following form:

(1)



Especially the nondistinctive clause is crucial, since it enables us to explain why particular feature values are generally preserved, while others never or seldomly are. Given the fact that prespecified feature values are preserved by VC, we do not have to add stipulations to the effect that one value is dominant over the other. Hence, we do not have to say, language after language, that [+round] is dominant over [-round], since it simply reflects the fact that [+round] is the lexical value in all languages having round vowels. Furthermore, the nondistinctness clause allows us to elucidate the absence of VC in certain vowel sequences but not in others. For example, two nonhigh vowels undergo merger, while sequences of high and nonhigh vowels do not in either Ancient Greek or Old Portuguese. We have argued that merger is blocked because high and nonhigh vowels are distinct at the stage of the derivation where VC is applicable.

The claim that VC is confined to the domain of the syllable accounts for a systematic gap in the data. In none of the VC languages do we find heterosyllabic vowel sequences that have undergone VC. The claim that resyllabification feeds VC implies that coalescence of heterosyllabic vowels fails to occur. Furthermore, given this claim, we can distinguish between true and apparent VC languages. It turned out that, for instance, Tunica is a vowel harmony language and not a VC language. Without the tautosyllabicity requirement we cannot draw a principled distinction between these two types of vowel-affecting processes.

Finally, the claim that VC induces a purely melody-internal change accounts for the observation that the output vowel is uniformly long, unless language-specific processes undo this result. The latter situation exists in Korean, where G+V merge into a short vowel, while V+V merge into a long vowel (G = glide, V = vowel). The reason for this length difference is due to the representation of rising diphthongs, which are associated to a single V-slot.

The following chapters put this theory to the test. Chapters 3 and 4 were entirely devoted to the description of vowel processes appearing in the Attic dialect of Ancient Greek. In chapter 3, we discussed some important aspects of its phonological system. We claimed that the surface vowel system consisting of five short and seven long vowels derives from an underlying five-vowel system. Furthermore, we provided evidence for the claim that the mid vowel /e/ is the default vowel, unspecified for all vocalic features. In Attic, the vowel /e/ behaves differently from the other vowels in many respects. It turned out that all stem-vowel alternations involve /e/, that is, there appear to be alternations of the type poli- versus pole- 'state', whereas alternations like poli- versus *polu-, *pola-, and so forth, do not occur. Furthermore, morphological word-formation processes such as Perfect Reduplication, Augmentation and Tense Formation make use of an empty V-slot which shows up as [e] if it is surrounded by consonants, while in the vicinity of vowels it acquires the quality of the vowel that flanks it. We also discussed the most important rules of Ancient Greek which involved vocalic alternations, and showed that these rules find a straightforward account within the theory developed.

The main interest of Ancient Greek follows from the presence of an intricate system of VC, which is, as far as we have been able to ascertain, by far the most complicated VC system attested in natural languages. We argued in chapter 4 that the VC facts emerge from two separate and formally distinct rules of Leftward Spreading and Vowel Coalescence. From a diachronic point of view, all VC facts aspparently arose from a single rule of vowel contraction which remained productive over a long period of time. Synchronically, however, the facts are diverse enough to prohibit formulating a single rule, at the risk of having to accept a tremendous loss of generality.

The rule of Leftward Spreading spreads the complete set of features of a vowel (root node spreading) to an empty V-slot to its left. The rule of Vowel Coalescence, on the other hand, involves the merger of two nondistinct supralaryngeal nodes dominated by the same syllable node. The assumption of two rules makes our analysis different from all previous ones (cf. Sommerstein 1973, Wetzels 1986). However, the empirical facts unequivocally point to the correctness of our proposal. First of all, the output of e+V coalescence, but not the output of a+V coalescence, undergoes the independently motivated rule of /ā/-Fronting, which changes /ā/ into [ε̄]. Underlying /ā/'s (e.g. /phā-mi/ → [phε̄mí] 'say'), /ā/'s arising by merger of e+a (e.g. /gene-a/ → [génε̄] 'race') and /ā/'s which result from the first compensatory lengthening (e.g. /egamsa/ → [égε̄ma] 'marry') undergo /ā/-Fronting, while /ā/'s which arise by a+e merger (e.g. /tīma-ete/ → [tīmâte] 'honor') and the second compensatory lengthening (e.g. /pansa/ → [pâsa] 'all') do not. Second, if the sequence e+V, where V is not /e/, results from the deletion of an intervening /w/, the hiatus is not resolved (e.g. /dew-omen/ → [déomen] 'we sail'). However, e+e sequences which arise by application of the same /w/-Deletion rule merge freely (e.g. /dew-ete/ → [dête] 'you (pl.) sail'). Finally, the merger of e+V is conditioned by the Bisyllabicity Condition, which precludes the resolution of vocalic hiatus if the input word is bisyllabic (e.g. /theós/ → *[thōs] 'god' vs. [thṓmantis] proper name). The merger of a+V and o+V is not restricted in this way (e.g. /dra-eys/ → [drâys] 'you do'). Hence, there appeared to be a great number of properties that distinguish e+V coalescence from the other types of coalescences. By positing two formally distinct rules, we account for them straightforwardly, while a single rule of VC must include all differences in the statement of the rule itself, and the clustering of the properties remains purely accidental.

Chapter 5 examined vowel coalescence in a variety of languages. We showed that only a small subset of the languages previously included in the set of VC languages actually satisfy the criteria established in chapter 2. We discussed Quebec French, Korean, Rotuman, Classical Sanskrit and Old Portuguese, because they provided additional confirmation for a number of claims made earlier. VC in Quebec French supports the claim that VC involves the merger of supralaryngeal nodes in the feature tree, since in this language both the place and nasal features are preserved by VC, and the supralaryngeal node is the first node that dominates both the nasal tier and the place tier. Korean and Rotuman were discussed because these languages strengthen the claim that all prespecified feature values are preserved even though the resulting vowels do not occur underlyingly. These languages indicate that a distinction must be made between structure preservation at the distinctive feature level and structure preservation at the phoneme level. Vowel coalescence in Korean and Rotuman shows that the notion of structure preservation must be defined at the level of distinctive features, and not at the level of the underlying phonemes of a language. VC in Classical Sanskrit and Old Portuguese was discussed in support of the claim that vowel merger takes place if and only if the merging vowels are nondistinct. In Sanskrit high and nonhigh vowels are still nondistinct at the stage of the derivation where VC applies. In Old Portuguese, on the other hand, high and nonhigh vowels become distinct by means of Vowel Raising, a rule ordered before and bleeding VC.

Finally, we examined a number of apparent VC languages. In each case, the absence of at least one of the basic properties of VC generated suspicion as to whether they actually are, and we were able to argue that the simplest grammar for each of them was one lacking a rule of VC. The apparent vowel mergers were derivable by independently motivated processes.

The overall discussion of vowel coalescence in this thesis shows that there are essentially two types of assimilatory processes. In the first type, a distinction must be made between trigger and target, and the target acquires a feature or a feature complex from the trigger. In the second type, it is very hard or even impossible to distinguish between trigger and target, and segments simultaneously serve as both focus and environment. This crucial difference motivated us to distinguish autosegmental spreading from autosegmental merger. The fact that in vocalic hiatus the vowels mutually assimilate without it being entirely clear which is the trigger and which the target, provides the prime motivation for including merger among the basic autosegmental operations, besides the well-established spreading, association and deassociation operations. The version of autosegmental phonology developed here is in no respect less restrictive than previous ones, since from the outset autosegmental theory has allowed for (universal) merger-like principles such as the Obligatory Contour Principle (Goldsmith 1976), the Shared Features Convention (Steriade 1982), the Twin Sister Convention (Clements and Keyser 1983), and the Nuclear Fusion Principle (Wetzels 1986).

Aitchison, J. 1976. "The Distinctive Features of Ancient Greek". Glotta 54, 173-201.

Akinlabi, A.M. 1984. Tonal Underspecification and Yoruba Tone. Ph.D. dissertation, University of Ibadan.

Allen, W.S. 1972. Sandhi. The Theoretical, Phonetic and Historical Bases of Word-Junction in Sanskrit. Den Haag: Mouton.

—— 1973. Accent and Rhythm. Cambridge: Cambridge University Press.

Anderson, S. 1969. West Scandinavian Vowel Systems and the Ordering of Phonological Rules. Ph.D. dissertation, MIT, Cambridge. [later published by Indiana University Linguistics Club].

—— 1970. "On Grassmann's Law in Sanskrit". Linguistic Inquiry 1, 387-396.

Anderson, J.M., C.J. Ewen 1987. Principles of Dependency Phonology. Cambridge: Cambridge University Press.

Archangeli, D. 1984. Underspecification in Yawelmani Phonology and Morphology. Ph.D. dissertation, MIT, Cambridge.

—— and D. Pulleyblank 1986. "The Content and Structure of Phonological Representations". ms. University of Arizona and University of Southern California.

Armstrong, L.E. 1940. The Phonetic and Tonal Properties of Kikuyu. International African Institute. London: Dawsons of Pall Mall.

Aronoff, M. Word Formation in Generative Grammar. Cambridge: MIT Press.

Baker, M. 1985. Incorporation: a Theory of Grammatical Function Changing. Ph.D. dissertation, MIT, Cambridge.

Barker, M.A.R. 1964. Klamath Grammar. Berkeley: University of California Press.

Bartoněk, A. 1966. Development of the Long-Vowel System in Ancient Greek Dialects. Praha.

Besnier, N. 1987. "An Autosegmental Approach to Metathesis in Rotuman". Lingua 73, 201-224.

Bichakjian, B.H. 1986. "A new Feature for the Specification of Four-Height Vowel Systems". Gramma 10, 105-117.

Biggs, B. 1965. "Direct and Indirect Inheritance in Rotuman". Lingua 14, 383-445.

Booij, G.E. and J. Rubach 1987. "Postcyclic versus postlexical Rules in Lexical Phonology". Linguistic Inquiry 18, 1-44.

Broselow, E. and J.J. McCarthy 1983. "A Theory of Internal Reduplication". The Linguistic Review 3, 25-88.

Bubeník, V. 1983. The Phonological Interpretation of Ancient Greek: a Pandialectal Analysis. Toronto: University of Toronto Press.

Cairns, C.E. 1976. "Universal Properties of Umlaut and Vowel Coalescence". In: A. Juilland, A.M. Devine and L.D. Stephens (eds.), Linguistic Studies offered to Joseph Greenberg on the occasion of his sixteeth birthday, vol.2, 271-283.

Callow, J.C. 1965a. Collected Field Reports on the Phonology of Kasem.

The Institute of African Studies, University of Ghana.
—— 1965b. "Kasem Nominals: a Study in Analysis". Journal of West African Languages 2, 29-36.
Campbell, L. 1980. "The Phonological and Social Reality of Finnish Vowel Harmony". In: R.M. Vago (ed.), Issues in Vowel Harmony. Amsterdam: John Benjamin, 245-270.
Carnoy, A. 1925. Grammaire Elémentaire de la Langue Sanscrite. Paris: Libraire Orientaliste.
Chomsky, N. 1981. Lectures on Government and Binding. Dordrecht: Foris.
Chomsky, N. and M. Halle 1968. The Sound Pattern of English. New York: Harper and Row.
Christdas, P. 1986. "Morpheme Structure Constraints and Underspecification". paper read at the LSA meeting, New York.
—— 1987. The Phonology and Morphology of Tamil. Ph.D. dissertation, Cornell University, Ithaca.
Churchward, C.M. 1940. Rotuman Grammar and Dictionary. Sydney: The Australian Medical Publishing Company.
Clements, G.N. 1976. "Vowel Harmony in Nonlinear Phonology: an Autosegmental model". [later published by Indiana University Linguistics Club].
—— 1981. "Akan Vowel Harmony: a Non-Linear Analysis". In: G.N. Clements (ed.), Harvard Studies in Phonology 2, 108-177.
—— 1985. "The Geometry of Phonological Features". Phonology Yearbook 2, 225-252.
—— 1986a. "Compensatory Lengthening and Consonant Gemination in LuGanda". In: W.L. Wetzels and E. Sezer (eds.), Studies in Compensatory Lengthening. Dordrecht: Foris, 37-77.
—— 1986b. "Syllabification and Epenthesis in the Barra Dialect of Gaelic". In: K. Bogers, H. van der Hulst and M. Mous (eds.), The Phonological Representation of Suprasegmentals. Dordrecht: Foris, 317-336.
—— 1987a. "Phonological Feature Representation and the Description of Intrusive Stops". Proceedings of CLS 23.
—— 1987b. "The Role of Sonority Cycle in Core Syllabification". ms. Cornell University, Ithaca.
—— and K. Ford 1980. "On the Phonological Status of Downstep in Kikuyu". In: D.L. Goyvaerts (ed.), Phonology in the 1980's. Ghent: E. Story-Scientia, 309-357.
—— and J.A. Goldsmith (eds.) 1984. Autosegmental Studies in Bantu Tone. Dordrecht: Foris.
—— and S.J. Keyser 1983. CV Phonology: a Generative Theory of the Syllable. Cambridge, MIT Press.
—— and E. Sezer 1982. "Vowel and Consonant Disharmony in Turkish". In: H. van der Hulst and N. Smith (eds.), The Structure of Phonological Representations 2, Dordrecht: Foris, 311-336.
Dumas, D. 1978. Phonologie des réductions vocaliques en français québécois. Ph.D. dissertation, University of Montreal, Montreal.
Ewen, C. and H. van der Hulst 1985. "Single-Valued Features and the Non-

Linear Analysis of Vowel Harmony". In: H. Bennis and F. Beukema (eds.), Linguistics in the Netherlands 1985, Dordrecht: Foris, 39-48.

—— 1987. "Single-valued Features and the Distinction between [-F] and [OF]". In: F. Beukema and P. Coopmans (eds.), Linguistics in the Netherlands 1987, Dordrecht: Foris, 51-60.

Elugbe, B. 1972. "Assimilation and Elision in Urhobo and Ghotuo". In: Research Notes from the Department of Linguistics and Nigerian Languages 5, 45-49.

Fromkin, V.A. 1973. Speech Errors as Linguistic Evidence. The Hague: Mouton.

—— 1975. "When does a test test a hypothesis, or, What counts as evidence?". In: D. Cohen, J.R. Wirth (eds.), Testing Linguistic Hypotheses. New York: Hemisphere Publ. Co.

Goldsmith, J.A. 1976. Autosegmental Phonology. Ph.D. dissertation, MIT, Cambridge. [also 1979 New York: Garland Publishing Co.].

Goodwin, W.W. 1894. A Greek Grammar. London: MacMillan and Co.

Grammont, M. 1948. Phonétique du grec ancien. Lyon: IAC.

Haas, M.R. 1940. Tunica. Extract from Handbook of American Indian Languages 4, New York: J.J. Augustin Publisher.

Haas, W.G. de 1986a. "A CV Analysis of vowel hiatus in Kasem". In: H. Bennis and F. Beukema (eds.), Linguistics in the Netherlands 1985. Dordrecht: Foris, 61-69.

—— 1986b. "Partial Syllabification and Schwa Epenthesis in Dutch". Gramma 10, 143-161.

—— 1987a. "An Autosegmental Approach to Vowel Coalescence". Lingua 73, 167-199.

—— 1987b. "Statische versus dynamische feature-geometrie; een afweging op basis van Schwa-epenthese". Glot 10,

—— 1988a. "Phonological Implications of Skeleton and Feature Underspecification in Kasem". to appear in Phonological Yearbook 5.2.

—— 1988b. "Deaspiration in Classical Sanskrit". paper read at the annual LIN meeting, Leiden.

—— and B. Hermans (forthcoming). "The Relevance of the Notions of Syllable and Mora for the Ancient Greek Accent Rule".

Halle, M. 1959. The Sound Pattern of Russian. The Hague: Mouton.

—— 1978. "Further Thoughts on Kasem Nominals". Linguistic Analysis 4, 167-185.

—— 1987. "Why Phonological Strata should not include Affixation". ms. MIT, Cambridge.

—— and K.P. Mohanan 1985. "Segmental Phonology of Modern English". Linguistic Inquiry 16, 57-116.

—— and J-R. Vergnaud 1980. "Three Dimensional Phonology". Journal of Linguistic Research 1, 83-105.

Hammond, M.T. 1984. Constraining Metrical Theory: a Modular Theory of Rhythm and Destressing. Ph.D. dissertation, UCLA, Los Angeles.

Hayes, B.P. 1984. "The Phonetics and Phonology of Russian Voicing Assimilation". In: M. Aronoff and R.T. Oehrle (eds.), Language Sound

Structure, Cambridge: MIT Press, 318-328.
---- 1986a. "Inalterability in CV Phonology". Language 62, 321-351.
---- 1986b. "Assimilation and Spreading in Toba Batak". Linguistic Inquiry 17, 467-499.
---- 1987. "A Revised Parametric Metrical Theory". Proceedings of NELS 17.
Harris, J.W. 1980. "Nonconcatenative Morphology and Spanish Plurals". Journal of Linguistic Research 1, 15-31.
---- 1983. Syllable Structure and Stress in Spanish. Cambridge: MIT Press.
Hermans, B. 1985. "The Relation between Aspiration and Preaspiration in Icelandic". In: H. van der Hulst and N. Smith (eds), Advances in Nonlinear Phonology. Dordrecht: Foris, 237-265.
---- 1986. "On Deriving the Strict Cycle Condition in Phonology". paper read at the GLOW conference in Barcelona.
---- (forthcoming). The Tonal Accent of Limburgian and Croatian. Ph.D. dissertation, Katholieke Universiteit Brabant, Tilburg.
Hooper, J.B. 1976. An Introduction to Natural Generative Phonology. New York: Academic Press.
Ingria, R. 1980. "Compensatory Lengthening as a Metrical Phenomenon". Linguistic Inquiry 11, 465-496.
Itô, J. 1986. Syllable Theory in Prosodic Phonology. Ph.D. dissertation, University of Massachusetts, Amherst.
Itô, J. and R.A. Mester 1986. "The Phonology of Voicing in Japanese". Linguistic Inquiry 17, 49-73.
Jacobs, H. (forthcoming). "A Nonlinear Analysis of the Evolution of Consonant + Yod sequences in Gallo-Romance".
Jacobsen, W. 1964. A Grammar of the Washo Language. Ph.D. dissertation, University of California, Berkeley.
Kahn, D. 1976. Syllable-Based Generalizations in English Phonology. Ph.D. dissertation, MIT, Cambridge.
Kaye, J. 1982. "Harmony Processes in Vata". In. H. van der Hulst and N. Smith (eds.), The Structure of Phonological Representations 2. Dordrecht: Foris, 385-452.
Kaye, J., J. Lowenstamm and J-R. Vergnaud 1985. "The Internal Structure of Phonological Elements: a Theory of Charm and Government". Phonology Yearbook 2, 305-328.
Kean, M-L. 1975. The Theory of Markedness in Generative Grammar. Ph.D. dissertation, MIT, Cambridge.
Kenstowicz, M. 1970. "On the Notion of Vowel Length in Lithuanian". Papers in Linguistics 3, 73-113.
---- 1982. "Gemination and Spirantization in Tigrinya". Studies in Linguistic Science 12.
Kimenyi, A. 1979. Studies in Kinyarwanda and Bantu Phonology. Edmonton, Linguistic Research Inc.
Kiparsky, P. 1967. "A propos de l'histoire de l'accentuation grecque". Langages 8, 73-93.
---- 1968. "Linguistic Universals and Language Change". In: E. Bach and

R.T. Harms (eds.), Universals in Linguistic Theory. New York, Holt, Rinehart and Winston, 171-202.

—— 1971. "Historical Linguistics". In: W.O. Dingwall (ed.), A Survey of Linguistic Science. Linguistic Programm, University of Maryland, College Park, 567-649.

—— 1973. "Phonological Representations". In: O. Fujimura (ed.), Three Dimensions of Phonological Theory. Tokyo: TEC Co., 1-136.

—— 1979. "Metrical Structure Assignment is Cyclic". Linguistic Inquiry 10, 421-441.

—— 1981. "Vowel Harmony". ms. Stanford University.

—— 1982. "Lexical Morphology and Phonology". In: Linguistics in the Morning Calm. Seoul: Hanshin Publishing Co., 3-91.

—— 1984. "On the Lexical Phonology of Icelandic". In: C.C. Elert, I Johansson and E. Strangert (eds.), Nordic Prosody 3. Stockholm: Almqvist and Wiksell, 135-164.

—— 1985. "Some Consequences of Lexical Phonology". Phonology Yearbook 2, 85-138.

Kühner, R. and F. Blass 1890. Ausführliche Grammatik der Griechischen Sprache, Erster Teil. Hannover and Leipzig.

Ladefoged, P. 1971. Preliminaries to Linguistic Phonetics. Chicago: Chicago University Press.

Leben, W. 1973. Suprasegmental Phonology. Ph.D. dissertation, MIT, Cambridge.

Lehiste, I. 1985. "An Estonian Word Game and the Phonetic Status of Long Vowels". Linguistic Inquiry 16, 490-492.

Lejeune, M. 1972. Phonétique historique du Mycénien et du grec ancien. Paris: Editions Klincksieck.

Levin, J. 1985. A Metrical Theory of Syllabicity. Ph.D. dissertation, MIT, Cambridge.

Lightner, T. 1963. "A Note on the Formulation of Phonological Rules". Quaterly Progress Report of the Research Laboratory of Electronics, MIT 68, 187-189.

Marantz, A. 1981. "Re Reduplication". Linguistic Inquiry 13, 435-482.

Mascaró, J. 1976. Catalan Phonology and the Phonological Cycle. Ph.D. dissertation, MIT, Cambridge.

—— 1986. "A Reduction and Spreading Theory of Voicing and other Sound Effects". ms. Universitat Autonoma de Barcelona.

McCarthy, J.J. 1982. "Prosodic Templates, Morphemic Templates and Morphemic Tiers". In: H. van der Hulst and N. Smith (eds.), The Structure of Phonological Representations 1. Dordrecht: Foris, 191-223.

—— 1986. "OCP Effects: Gemination and Antigemination". Linguistic Inquiry 17, 207-263.

—— and A. Prince 1986. "Prosodic Morphology". ms. University of Massachusetts and Brandeis University.

Mohanan, K.P. 1982. Lexical Phonology. Ph.D. dissertation, MIT, Cambridge. [also 1986 Dordrecht: Reidel].

—— and T. Mohanan 1984. "Lexical Phonology of the Consonant System in Malayalam". Linguistic Inquiry 15, 575-602.

Murray, R.W. and T. Vennemann 1983. "Sound Change and Syllable Structure in Germanic Phonology". Language 59, 514-528.

Naro, A.J. 1971. "Resolution of Vocalic Hiatus in Portugese". Language 47, 381-393.

Nuñes, J.J. 1945. Compendio de Grammatica historica Portuguesa. Lisboa: Livraria Classica.

Odden, D. 1986a. "On the Role of the Obligatory Contour Principle in Phonological Theory". Language 62, 353-383.

—— 1986b. "Antigemination and the OCP". ms. Ohio State University.

Pesetsky, D. 1979. "Russian Morphology and Lexical Theory". ms. MIT.

Phelps, E. 1975a. "Sanskrit Diaspirates". Linguistic Inquiry 6, 447-464.

—— 1975b. "Simplicity Criteria in Generative Phonology: Kasem Nominals". Linguistic Analysis 1, 297-332.

—— 1979. "Abstractness and Rule Ordering in Kasem: a Refutation of Halle's Maximizing Principle". Linguistic Analysis 5, 29-69.

Poser, W.J. 1982. "Phonological Representations and Action-at-a-Distance". In: H. van der Hulst and N. Smith (eds.), The Structure of Phonological Representations 2. Dordrecht: Foris, 121-158.

Pulleyblank, D. 1983. Tone in Lexical Phonology. Ph.D. dissertation, MIT, Cambridge. [revised version published 1986 Dordrecht: Reidel]

Redenbarger, W.J. 1981. Articulator Features and Portuguese Vowel Height. Cambridge: Harvard University Press.

Rochette, A. 1980. "On Rules of Diphthongization and Vowel Contraction". ms. MIT.

Ruijgh, C.J. 1968. "Observations sur la 'métathèse de quantité'". Lingua 21, 382-399.

—— 1972. "Le redoublement dit attique dans l'évolution du système morphologique du verbe grec". In: Mélanges de linguistique et de philologie grecques offerts a Pierre Chantraine. Paris: Editions Klincksieck.

—— 1975. "Analyse morphologique de l'attique classique". Mnemosyne 8, vol. XVII-XXIX.

—— 1976. Review A.H. Sommerstein, "La Phonologie générative du grec ancien". Foundations of Language 14, 561-586.

—— 1984. "Le dorien de Théocrite: dialecte cyrénien d'Alexandrie et d'Egypte". Mnemosyne 37, 56-88.

Sag, I. 1974. "The Grassmann's Law Ordering Pseudoparadox". Linguistic Inquiry 5, 591-607.

—— 1976. "Pseudosolutions to the Pseudoparadox: Sanskrit Diaspirates Revisited". Linguistic Inquiry 7, 609-622.

Sagey, E. 1986a. "On the Representation of Complex Segments and their Formation in Kinyarwanda". In: W.L. Wetzels and E. Sezer (eds.), Studies in Compensatory Lengthening. Dordrecht: Foris, 251-295.

—— 1986b. The Representation of Features and Relations in Non-Linear Phonology. Ph.D. dissertation, MIT, Cambridge.

Schane, S.A. 1984a. "Two English Vowel Movements: a Particle Analysis". In: M. Aronoff and R.T. Oehrle (eds.), Language Sound Structure. Cambridge: MIT Press, 32-51.

—— 1984b. "The Fundamentals of Particle Phonology". Phonology Yearbook 1, 129-155.

Schein, B. 1981. "Spirantization in Tigrinya". In: H. Borer and J. Aoun (eds.), Theoretical Issues in the Grammar of Semitic Languages, MIT Working Papers in Linguistics 3, Cambridge.

—— and D. Steriade 1986. "On Geminates". Linguistic Inquiry 17, 691-744.

Schindler, J. 1976. "Diachronic and Synchronic Remarks on Bartholomae's and Grassmann's Law". Linguistic Inquiry 7, 622-637.

Schwyzer, E. 1939. Griechische Grammatik, Erster Teil. München.

Selkirk, E.O. 1984. "On the Major Class Features and Syllable Theory". In: M. Aronoff and R.T. Oehrle (eds.), Language Sound Structure. Cambridge: MIT Press, 107-136.

Sharp, A.E. 1960. "Vowel Length and Syllabicity in Kikuyu". African Language Studies 1, 42-59.

Shattuck-Hufnagel, S. and D.H. Klatt 1979. "The Limited use of Distinctive Features and Markedness in Speech Production: Evidence from Speech Error Data". Journal of Verbal Learning and Verbal Behavior 18, 41-55.

Siegel, D. 1974. Topics in English Morphology. Ph.D. dissertation, MIT, Cambridge.

Smith, N.S.H. 1985. "Spreading, Reduplication and the Default Option in Miwok Nonconcatenative Morphology". In: H. van der Hulst and N. Smith (eds.), Advances in Nonlinear Phonology. Dordrecht: Foris, 363-380.

—— and B. Hermans 1982. "Nonconcatenatieve woordvorming in het Sierra Miwok". Glot 5, 263-284.

Sohn, H-S. 1987. "On the Representation of Vowels and Diphthongs and their Merger in Korean". Proceedings of CLS 23.

Sommerstein, A.H. 1973. The Sound Pattern of Ancient Greek. Oxford: Basil Blackwell.

Sproat, R. 1985. On Deriving the Lexicon. Ph.D. dissertation, MIT, Cambridge.

Stanley, R. 1967. "Redundancy Rules in Phonology". Language 43, 393-436.

Steriade, D. 1982. Greek Prosodies and the Nature of Syllabification. Ph.D. dissertation, MIT, Cambridge.

—— 1987a. "Locality Conditions and Feature Geometry". Proceedings of NELS 17.

—— 1987b. "Redundant Values". Proceedings of CLS 23.

Trommelen, M. and W. Zonneveld 1979. Inleiding in de Generatieve Fonologie. Muiderberg: Coutinho.

Trubetzkoy, N. 1939. Principles of Phonology. English translation 1969 by C. Baltaxe. University of California Press.

Ultan, R. 1971. "A Typological View of Metathesis". Working Papers of Language Universals 7, 1-44.

Vogel, I. 1977. The Syllable in Phonological Theory with special reference to Italian. Ph.D. dissertation, Stanford University, San Francisco.

Wetzels, W.L. 1985. "The Historical Phonology of Intrusive Stops: a Nonlinear Description". Canadian Journal of Linguistics 30, 285-333.

—— 1986. "Phonological Timing in Ancient Greek". In: W.L. Wetzels and E. Sezer (eds.), Studies in Compensatory Lengthening. Dordrecht: Foris, 297-344.

—— 1988. "Theoretical Implications of Brazilian Potuguese Postcyclic Phonology". paper read at the Linguistic Symposium on Romance Languages 18, University of Illinois at Urbaba-Champaign.

—— and E. Sezer (eds.) 1986. Studies in Compensatory Lengthening. Dordrecht, Foris.

Whitney, W.D. 1889. Sanskrit Grammar. Cambridge: Harvard University Press.

Williams, E.B. 1962. From Latin to Portuguese. Philadelphia: University of Pennsylvania Press.

Williams, E. 1976. "Underlying Tone in Margi and Igbo". Linguistic Inquiry 7, 463-484.

Winter, W. 1970. "Reduplication in Washo: a Restatement". International Journal of American Linguistics 36, 190-198.

Yip, M. 1982. "Reduplication and C-V Skeleta in Chinese Secret Languages". Linguistic Inquiry 13, 637-661.

—— 1988. "The Obligatory Contour Principle and Phonological Rules: A Loss of Identity". Linguistic Inquiry 19, 65-100.

Zonneveld, W. 1978. A Formal Theory of Exceptions in Generative Phonology. Dordrecht: Foris.

Zwicky, A.M. 1965. Topics in Sanskrit Phonology. Ph.D. dissertation, MIT, Cambridge.

SAMENVATTING

EEN FORMELE THEORIE OVER VOKAALFUSIE:
een diepte-analyse van het Oudgrieks

Het centrale thema van deze studie is de formele beschrijving van vokaalfusie vanuit het perspectief van de Universele Grammatica. Als zodanig is het bedoeld als een bijdrage aan het huidige onderzoek naar de formele aspecten van de generatieve fonologie. In het bijzonder worden in deze dissertatie een aantal formele noties ter discussie gesteld en geherformuleerd. Het verschijnsel van vokaalfusie wordt onderzocht in een variëteit van talen, maar speciale aandacht wordt besteed aan de beschrijving van vokaalfusie in het Oudgrieks.

Vokaalfusie is een verschijnsel waarbij twee vokalen in hiaat samensmelten tot één (nieuwe) vokaal. Het resultaat van fusie is een vokaal waarbij de contrastieve eigenschappen van beide inputvokalen bewaard blijven.

De vragen waarop deze studie een antwoord wil geven zijn: (i) op welke wijze kunnen de fundamentele eigenschappen van vokaalfusie verantwoord worden binnen het model van de nonlineaire fonologie, en (ii) hoe kan de fonologische theorie zodanig ingericht worden dat alle voorkomende processen van vokaalfusie beschreven kunnen worden, terwijl alle afwezige vormen van vokaalfusie uitgesloten worden.

Het idee dat ontvouwd en gemotiveerd wordt is dat vokaalfusie een proces is dat plaatsvindt binnen de syllabe, waarbij de lexikaal gespecificeerde featurewaarden van beide inputvokalen samensmelten tot een nieuwe featureconstellatie. Bovendien wordt betoogd dat de samensmelting van featurematrixen alleen is toegestaan als de inputvokalen nondistinct zijn op het moment waarop vokaalfusie plaatsvindt, dat wil zeggen als het ene segment gespecificeerd is als [-F] en het andere segment als [+F] dan is fusie uitgesloten. Als daarentegen het ene segment gespecificeerd is als [+F] (of [-F]]) en het andere segment is eveneens [+F] of [0F] (= ongespecificeerd voor [F]) dan is fusie toegestaan. Deze conditie stelt ons in staat om te verantwoorden waarom bijvoorbeeld in het Oudgrieks twee niet-hoge vokalen contraheren tot een lange monoftong, terwijl een niet-hoge vokaal gevolgd door een hoge vokaal samensmelten tot een diftong.

Het onderzoek vindt plaats binnen het kader van de nonlineaire fonologie en met name de autosegmentele variant hiervan, hoewel de metrische variant ook zijdelings ter sprake wordt gebracht. Het belangrijkste verschil met het standaard model, zoals ontvouwd in Chomsky en Halle (1968), is dat fonologische representaties drie-dimensionaal zijn. Een fonologische representatie bestaat grofweg uit drie niveau's van representatie: (i) het skelet, waarop de kwantitatieve eigenschappen van segmenten worden gerepresenteerd, (ii) de melodie, waarop de kwalitatieve eigenschappen worden gerepresenteerd, en (iii) de prosodie, waarop suprasegmentele eigenschappen, zoals toon, klemtoon en syllabificatie verantwoord worden. In deze dissertatie wordt op basis van vokaalfusie betoogd dat het nonlineaire beschrijvingsmodel superieur is aan het lineaire model, aangezien de fundamentele eigenschappen van vokaalfusie op een nonarbitraire en inzichtgevende wijze beschreven kunnen worden.

Dit proefschrift valt uiteen in drie delen. De hoofdstukken 1 en 2 zijn theoretisch van opzet. In het tweede deel (hoofstuk 3 en 4) staat de fonologie van het Oudgrieks centraal en in het laatste deel wordt de ontwikkelde theorie getoetst aan een aantal echte en ogenschijnlijke vokaalfusietalen.

In hoofdstuk 1 wordt ingegaan op de vorm van fonologische representaties, de relaties tussen fonologische features, en universele beperkingen op de toepassing van fonologische processen. In sectie 1.1 wordt een theorie ontvouwd waarbij features hierarchisch georganiseerd worden via een mechanisme van 'tierdecompositie' dat een bundel ongeordende features herstructureert tot kleinere eenheden die hierarchisch geordend zijn. Vervolgens (sectie 1.2) wordt een onderspecificatietheorie voorgesteld die gezien kan worden als de synthese van de voorstellen in Archangeli (1984) en Steriade (1987b). De secties 1.3 en 1.4 zijn respectievelijk gewijd aan de Linking Constraint en de Strict Cycle Condition. Beide zijn condities op de werking van fonologische processen en betoogd wordt dat zij onafhankelijke evidentie opleveren voor de in sectie 1.2 behandelde onderspecificatietheorie.

Hoofdstuk 2 is geheel gewijd aan de eigenschappen van vokaalfusie en de manier waarop deze eigenschappen op een adequate wijze verantwoord kunnen worden. Na een overzicht van de lineaire en nonlineaire literatuur over vokaalfusie wordt de stelling geponeerd dat vokaalfusie opgevat dient te worden als de fusie van twee tautosyllabische, nondistincte knopen in de featurehierarchie.

In hoofdstuk 3 wordt een gedetailleerde beschrijving gegeven van het vokaalsysteem van het Oudgrieks en in het bijzonder het Attische dialect. Op basis van de onderspecificatietheorie uit sectie 1.2 wordt voorgesteld om de vokalen zodanig te representeren dat de /e/ volledig ondergespecificeerd is (sectie 3.2). Vervolgens wordt dit voorstel gemotiveerd via stamvokaalalternanties, woordformatieprocessen als Augmentation en Perfect Reduplication en fonologische processen als Stem Vowel Lowering, /ā/-Fronting en Metathesis of Quantity.

Het complexe systeem van vokaalfusie, zoals zich dat manifesteert in het Attisch staat centraal in hoofdstuk 4. Er wordt voorgesteld een tweedeling aan te brengen in de contractiefeiten, waarbij de e+V sequenties samensmelten via het onafhankelijk gemotiveerde Leftward Spreading, terwijl de overige sequenties contraheren via een vokaalfusieregel die voldoet aan de criteria uit hoofdstuk 2. Bovendien wordt uitvoerig ingegaan op het verschillend gedrag van hoge vokalen in hiaat. Er wordt betoogd dat, in het geval van prevokalische hoge vokalen, hersyllabificatie en fusie geblokkeerd worden door een proces van Homorganic Glide Insertion, terwijl in het geval van postvokalische hoge vokalen alleen fusie geblokkeerd wordt en wel op grond van de specificatie van niethoge vokalen als [-hoog] en hoge vokalen als [+hoog]. Zij voldoen hierdoor niet aan de structurele omschrijving van de vokaalfusieregel.

Tot slot wordt in hoofdstuk 5 vokaalfusie vanuit een taalvergelijkend perspectief bezien. Er wordt een onderscheid aangebracht tussen 'echte' en 'ogenschijnlijke' vokaalfusietalen op basis van de criteria uit hoofstuk 2. In de secties 5.1 tot en met 5.4 worden talen als het Quebec Frans, Koreaans, Rotuman, Oudportugees en Klassiek Sanskrit behandeld. Deze talen bevestigen de theorie zoals voorgesteld in hoofdstuk 2. Bovendien verschaffen zij evidentie voor de ontwikkelde theorie die niet op grond van het Oudgrieks verkregen kon worden. Zo bevestigt het Quebec Frans de claim dat niet alleen de vocalische features, maar ook een primair consonantisch feature als [nasaal] behouden blijft als minstens één van de inputvokalen gespecificeerd is als [+nasaal]. Het Koreaans en het Rotuman ondersteunen de stelling dat lexikaal gemarkeerde featurewaarden bewaard blijven ook al is het resultaat van fusie een vokaal die in het onderliggend vokaalsysteem ontbreekt. In beide talen worden de geronde voorvokalen [ü] en [ö] gegenereerd via een lexikale vokaalfusieregel. In sectie 5.5 worden ten slotte talen behandeld die minimaal één van de fundamentele criteria schenden. Voor deze talen (Kasem, Kikuyu, Tunica en Washo) worden analyses voorgesteld zonder vokaalfusieregels. In alle gevallen blijkt de ogenschijnlijke vokaalfusie een bijprodukt van onafhankelijk gemotiveerde processen.

CURRICULUM VITAE

The author was born on January 11, 1957 in Lienden. In 1976 he graduated from high-school (Atheneum-A of the Wagenings Lyceum in Wageningen). He then began his studies of Dutch Linguistics and Literature at the University of Utrecht, and received his bachelor's degree in 1980 and his master's degree (cum laude) in 1984, his major being General Linguistics, with minors in Dutch Linguistics and Computer Linguistics. From September 1984 till March 1988 he worked at the Department of French Linguistics and Literature of the Catholic University Nijmegen, investigating vowel coalescence in a variety of languages. During this period he spent 7 months at Cornell University, Ithaca, New York (September 1986 til April 1987) as visiting scholar, which was supported by the Netherlands Organization for the advancement of research (N.W.O.). Presently, he is affiliated to the Institute of Dutch Lexicology in Leiden, doing research in Dutch morphology.

STELLINGEN

behorende bij het proefschrift

A Formal Theory of Vowel Coalescence

a Case Study of Ancient Greek

van Willem Gerrit de Haas

te verdedigen aan de Katholieke Universiteit te Nijmegen

op maandag 31 oktober 1988 te 15.30 uur

1.

De aanname in de nonlineaire fonologie dat fonologische representaties hierarchisch georganiseerd zijn, kan gezien worden als de uitwerking van Chomsky en Halle's uitspraak "It seems likely...that ultimately the features themselves will be seen to be organised in a hierarchical structure...".

(cf. N. Chomsky & M. Halle (1968), The Sound Pattern of English. New York: Harper & Row, p.300.)

2.

Hiaatvermijdingsprocessen als vokaalfusie en vokaaldeletie dienen opgevat te worden als reacties op een sonoriteitsconflict.

3.

De hypothese, zoals geformuleerd in Kiparsky (1985), dat binnen de fonologische component tussen het onderliggende en het oppervlakteniveau van representatie een lexicaal niveau gepostuleerd moet worden, is reeds van voldoende kritische kanttekeningen voorzien in Halle (1959).

(cf. M. Halle (1959), The Sound Pattern of Russian. The Hague: Mouton;

P. Kiparsky (1985), "Some Consequences of Lexical Phonology". Phonology Yearbook 2, 85-138.)

4.

In Ewen en Van der Hulst (1987) kan een éénwaardig featuresysteem slechts gehandhaafd worden door een meerwaardig 'class feature' systeem te introduceren dat qua beschrijvende kracht vergelijkbaar is met een binair featuresysteem, waarbij gebruik gemaakt wordt van onderspecificatie.

(cf. C. Ewen & H. van der Hulst (1987), "Single-valued Features and the distinction between [-F] and [0F]". In: F. Beukema & P. Coopmans (eds.), Linguistics in the Netherlands 1987. Dordrecht: Foris, 51-60.)

5.

Het onderscheid tussen <u>derivatie</u> enerzijds en <u>inflexie</u> anderzijds, dat in beschrijvingen van het moderne Standaard Nederlands veelal wordt gemaakt, vindt in voldoende mate ondersteuning in de taalfeiten.

(reactie op stelling 2 behorend bij de dissertatie van H. Schultink, <u>De morfologische valentie van het ongeleed adjectief in het modern Nederlands</u>. diss. universiteit van Leiden, 1962.)

6.

Christdas' hantering van de notie 'gemarkeerdheid', zoals die tot uiting komt in het volgende citaat, moet als theoretisch onbruikbaar van de hand gewezen worden: "The class of voiced obstruents, however, is less marked than the class of voiceless sonorants, as the former occurs with greater frequency than the latter".

(cf. P. Christdas (1988), <u>The Phonology and Morphology of Tamil</u>. Ph.D. diss. Cornell University, Ithaca, NY, p.110.)

7.

Vanuit het oogpunt van taalkundige welgevormdheid zouden op de kentekenplaten van auto's en motoren cijfer- en lettercombinaties als 'GR-OO-TS' en '16-PO-ND' in de toekomst niet systematisch vermeden moeten worden.

8.

Nu universiteiten de financiële beloning van jonge onderzoekers reeds vergaand hebben teruggebracht, dienen zij op korte termijn zorg te dragen voor een reductie van de promotiekosten van de laatstgenoemden.

9.

Bovenstaande stellingen zullen in tegenstelling tot Luthers' 95 stellingen niet tot een schisma leiden. (31 oktober, hervormingsdag)

Printed by ICG Printing, Dordrecht